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Editorial Board

A Back Propagation Neural Network Intrusion Detection System Based on KVM

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ABSTRACT

A Network Intrusion Detection System (NIDS) monitors a network for malicious activities or policy violations [1]. The Kernel-based Virtual Machine (KVM) is a full virtualization solution for Linux on x86 hardware virtualization extensions [2]. We design and implement a back-propagation network intrusion detection system in KVM. Compared to traditional Back Propagation (BP) NIDS, the Particle Swarm Optimization (PSO) algorithm is applied to improve efficiency. The results show an improved system in terms of recall and precision along with missing detection rates.

Keywords—NIDS, KVM, back-propagation, PSO algorithm

I. INTRODUCTION

The rapid development of cloud computing provides a new computing model for users with powerful and cheap customized services including networks, servers, storage, and applications [2].

A. Background

The continuous improvement of cloud computing technology and competition among cloud providers help users spend less in exchange for enhanced cloud resources. This enables legitimate users to experience greater benefits by using cloud services with better quality. On the other hand, it simultaneously enables malicious users to pay less to contract a substantial configuration of cloud resources for launching an attack, which threatens other legitimate users on the same cloud platform. The existing security technology in cloud computing environments is facing various problems, such as large amounts of data, concurrent access, hardware resource sharing, and network compatibility. Compared with traditional computer systems, cloud computing is more prone to large-scale, dangerous attacks. Users store important information in the cloud platform from which malicious users may launch attacks or steal information. The intruder may also use the powerful computing capabilities of the cloud platform for malicious attacks on its own virtual machine. Typical attacks include the Resident attack, Trojan, and Distributed Denial-of-Service (DDoS) attacks. In other words, with the rapid development of cloud services, cloud computing applications are facing enhanced security threats.

B. Virtual Network Environment Security

The critical structural differences between cloud computing and traditional systems result in traditional intrusion detection techniques not fitting in the cloud computing virtualization environment. All services are provided by the server virtual machine where the security mechanism is deployed. To ensure the safe operation of the virtual machine, the intrusion detection system must be installed on all virtual machines on the same server in the cloud detection system. There are usually many virtual machines on each cloud server, so the above scheme will require a significant amount of the cloud service provider's computer resources, which greatly reduces the overall performance of the platform. To solve this problem, the intrusion detection system is deployed on a privileged virtual machine, which is responsible for the intrusion detection of all other virtual machines on the same server.

Today, mainstream network security technologies include encryption, firewall, and intrusion detection systems. As a common intrusion detection technology, the artificial neural network (ANN) includes

capabilities such as nonlinear elastic modeling, strong generalization, learning, and large-scale parallel computing [3]. The forward neural network is one of the most widely used neural networks, and the BP neural network is one of the most commonly used feedforward neural networks. The BP network, also known as the error back propagation network, is a multi-layer mapping network that transmits information forward with the minimum error propagating backward. A single hidden layer BP neural network can approximate any nonlinear function with arbitrary precision. This characteristic makes the BP neural network a common nonlinear detection system.

II. LITERATURE REVIEW

A significant amount of literature exists on cloud computing virtualization security research. Ficco et al. [4] introduce cloud computing in virtual environments and a variety of safety-related research results from different aspects, such as IDS and honeypot. Patel et al. [5] and Su et al. [6] list and analyze a variety of cloud computing environment intrusion detection technologies and the detection strategies. Lee and Yu [7] summarize the detection and defense model in a cloud environment. To ensure the security of a cloud computing network, an intrusion detection system (IDS) acts as the second line of defense in the computer network. It is responsible for processing and analyzing key information from internal and external computer networks to collect and then raise alarms for any violations of the security policy. A new virtual self-checking system is proposed in [8] to protect Kernel-based Virtual Machines (KVM) from a malicious attack on the virtual machine. However, the study needs to establish a complete set of rules in advance. Nantes et al. proposed a way for IDS to establish an efficient model to gain the optimal number of features with reduced usage of computer resources including memory and CPU time [9]. To deal with a large number of network access streams, control data, and applications in the cloud, Dhage and Meshram proposed a new multi-thread distributed intrusion detection model, which effectively integrates knowledge and behavior analysis into intrusion detection while processing, analyzing, and generating a large number of data streams [10]. However, this model is more complex and offers low efficiency.

Also, Rocha and Correia [11] show how malicious insiders can steal confidential data, indicating that the current cloud computing application environment contains many security vulnerabilities. Greamo and Gosh [12] cited the impact of malware on the cloud computing environment, and Hegazy et al. [13] use agent-based technology to describe the framework of intrusion detection in cloud computing. HishamA.Kholidy et al. [1] presents a computational framework for an intrusion detection system (IDS) deployed in all nodes including databases in the cloud, which may cause central server overload, communication, and excessive computation cost of each node.

III. KEY TECHNOLOGY OF KVM AND IDS

A. KVM

Virtualization is the abstraction of computing resources, such as servers, networks, memory, and storage, to enhance functionalities [14]. According to the definition of virtualization, a variety of computer resources are virtual objects, such as software, hardware, and the network. The functions available in the non-virtual environments can nearly all be realized in a virtual environment. Also, the virtual computer resources are merely logical resources for users. KVM is a fully virtualized technology based on the Linux environment and is responsible for the completion of the Linux kernel virtualization features running on x86 and x64 architectures. It is a kernel module in the Linux kernel, which is a virtual machine monitor in the Linux environment.

B. IDS

Two types of intrusion detection methods are common: misuse detection and anomaly detection [15]. Misuse detection first analyzes various possible intrusion behaviors and means, then summarizes the special collection of rules. In the process of detection, the matching rule is used to process the behavior of the detected object and then match the feature set and rule base. If the match is successful, the behavior is considered an intrusion. Anomaly detection records the past normal

behavior to establish a normal behavior model. When the behavior of the system is significantly different from the expected normal behavior, it is regarded as an intrusion behavior. Two common techniques used for anomaly detection are neural networks and swarm intelligence algorithms.

Intrusion detection processes usually involve the following: the system first obtains the required sample, then processes and analyzes the sample. Finally, the system proceeds according to the test results.

C. Back-propagation Neural Network

A BP neural network contains an input layer, a hidden layer, and an output layer [16]. The signal propagates forward by passing from the input layer to the output layer. The error is considered back propagating as it modifies the weights and thresholds according to the gradient descent algorithm [16]. The specific process is described as follows.

1)   Signal forward propagation
1. Obtain BP network training samples.
2. According to the structure and weight of the network, the signal passes from the input layer to the output layer.
   a. Calculate the output of the hidden layer as

   $$A_h = f(W_1^T X_h - b_1), \ h \in [1, hSize] \qquad (1)$$

   b. Calculate the output layer as

   $$A_o = f(W_2^T X_o - b_2), \ o \in [1, oSize] \qquad (2)$$

In equations (1) and (2), *hSize* is the number of nodes in the hidden layer, *oSize* is the number of nodes in the output layer, W1 and b1 represent the weights and thresholds of the input and hidden layers, respectively, W2 and b2 represent the weights and thresholds of the hidden and output layers, respectively, Ah is the output of the hidden layer, and Ao is the output of the output layer [17].

2)   Error back propagation
1. Calculate the mean square error (MSE) value based on the real output and the desired output of the network [17].
2. Adjust the weights and thresholds based on the method of minimizing errors.

The error signal passes from the output layer to the input layer. The weights are adjusted according to the error feedback method, which gradually brings the actual output of the network close to the desired output [17].

$$\Delta w^{(k+1)} = -\eta \, (\partial E^k)/(\partial \omega^k) + \alpha \Delta w^k \qquad (3)$$

In equation (3), $\Delta w^{(k+1)}$ is the modified vector of the first k+1 modification, η is the learning rate, and E^k is the error function of the neural network [17].

D. PSO algorithm

A BP network is very sensitive to the initial weights and thresholds. If the values and parameters are not set properly, it may cause shock effect and slow the convergence speed [18]. In this paper, PSO is used to search the optimal initial weights and thresholds of a BP neural network. PSO offers simple calculation and good robustness as well as good performance in multi-dimension continuous space, neural network training, combinatorial optimization, and other optimization problems. The primary particle swarm optimization algorithm for position and velocity update [19] is expressed as: $v_i(t+1) = \omega(t)v_i(t) + c_1 r_1(pBest_i(t) - x_i(t)) + c_2 r_2(gBest(t) - x_i(t))$

In this section, *v* represents speed, *x* represents the location, *i* is the current particle number, *t* is the current number of iterations, c_1 and c_2 are learning factors, r_1 and r_2 are random values in [0,1], PBest is the individual extremum for a single particle, and GBest is the global extremum found for the whole particle swarm [19].

Because of an increasing number of users in cloud computing and the cloud expansion of application environments, a malicious intrusion or attack on a cloud environment can interfere with the availability, confidentiality, and integrity of the resources and services of cloud computing service providers. An

IDS, as a kind of active monitoring technology and protection mechanism, can prevent the destruction of critical IT infrastructure. Intruders can destroy sensitive data and critical applications through network attacks.

IDS can be divided into the two categories of misuse detection and anomaly detection [15]. Previously, IDS could protect the cloud system from various types of attacks, but could not identify suspicious activities in a cloud environment. IDS can also be classified based on the source of the data. Host-based IDS intrusion detection sensors are focused on a single host, while IDS based on the network will put all the sensors on a sensor network segment. The anomaly detection mechanism can improve the ability of the system to detect unknown intrusion attacks, which is especially important in the virtual network model.

IV. METHODOLOGY

Based on the analysis of the KVM network structure, this paper proposes an intrusion detection model based on an improved BP neural network and a KVM NAT bridge structure. First, this model analyzes the KVM network model and uses the NAT bridge pattern to design the data capture module to retrieve the virtual machine's communication information. Next, it analyzes and extracts the data packets in turn, then sends the data to the neural network detection engine.

Several modules are included in this model. The data capture module sets the data capture mode based on the network mode of the virtual environment and submits the captured data to the data packet analysis module. The packet-parsing module analyzes the captured data packets based on the network protocol and submits the analytical results to the feature extraction module. Based on the characteristics of the intrusion detection system, the feature extraction module extracts the specific features from the data [20]. Based on the improved BP neural network algorithm, the engine determines whether the data is the invasion of the data, and the results are submitted to the intrusion response module.

Because the performance of the BP algorithm is largely dependent on the initial weights and thresholds, this research to improve the BP network is important to improve the convergence speed of the network. In this report, the PSO algorithm is introduced to optimize the initial weights and thresholds of the BP. The algorithm is based on momentum factor, adaptive learning rate, and PSO.

The design idea of the algorithm is as follows: The system combines the global search ability of the PSO algorithm and the gradient descent local search of the BP algorithm. The PSO algorithm is introduced into the optimization of the initial weights and thresholds of the BP. By using the momentum factor and adaptive learning rate methods, the convergence speed of the BP neural network is accelerated, and the local minimum is avoided. Finally, the algorithm is used to build an intrusion detection system in a cloud environment.

The specific process of the algorithm includes the following steps:

Step 1: initialize the parameters of BP neural network, set the number of nodes in each layer.

Step 2: initialize the parameters of the particle swarm and calculate the particle dimension D. The system initializes the cluster and generates parameters, such as the initial position and the velocity of the particle.

Step 3: calculate the fitness value of each particle compared with the current best fitness value, PBest. If the value is better, update PBest. Then, compare the PBest with the optimal global value of GBest. If the value is better, then use PBest to update GBest.

Step 4: update the inertia weight and adjust the position and speed of the particle.

Step 5: if current iteration achieves the maximum or error is in the scope, the initial weights and thresholds should be the current global extreme GBest, otherwise, return to Step 3.

Step 6: use the system to train the BP neural network, and establish the intrusion detection model with the initial weights and threshold optimization based on the value from Step 5.

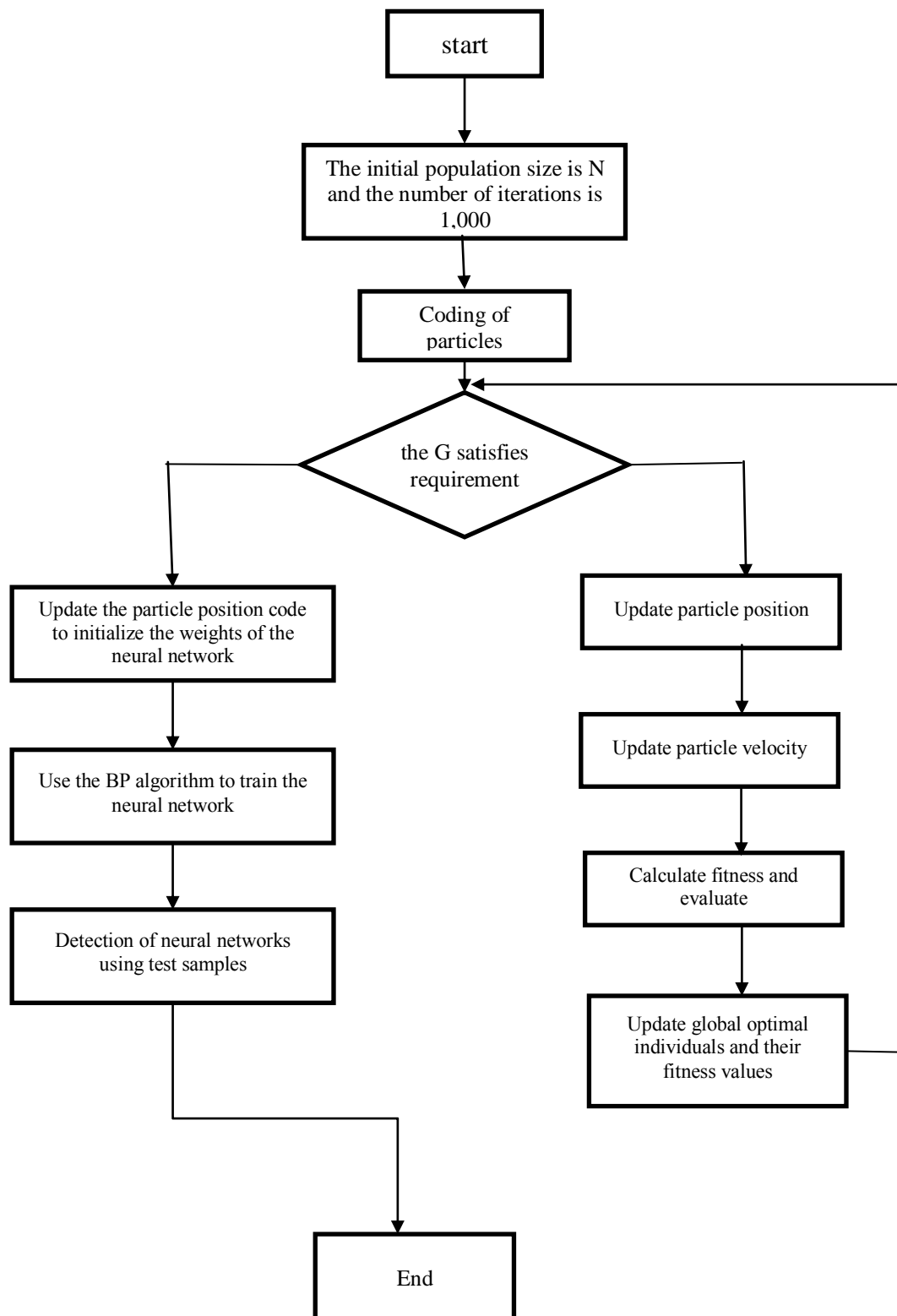A flowchart of the algorithm is shown in Fig. 1.

Figure 1. Structure of algorithm

To illustrate the feasibility and effectiveness of this algorithm, its performance is analyzed with experiments using the intrusion detection dataset KDD Cup 99 [21]. This is a commonly-used intrusion detection algorithm training and testing data set, which includes the majority of the types of attacks faced by cloud computing virtualization environments.

Each sample (connection record) in the KDD dataset contains 42 attributes, and their details and serial numbers are presented in Table I.

TABLE I.PROPERTIES OF RECORDS [21].

SID	property	SID	property	SID	property
1	Duration	15	Su_attempted	29	Sam_srv_rate
2	Protocol_type	16	Num_root	30	Diff_srv_rate
3	Service	17	Num_file_creations	31	Srv_diff_host_rate
4	Flag	18	Num_shells	32	Dst_host_count
5	Src_bytes	19	Num_access_file	33	Dst_host_srv_count
6	Dst_bytes	20	Num_outbound_cmds	34	Dst_host_same_srv_rate
7	Land	21	Is_hot_login	35	Dst_host_diff_srv_rate
8	Wrong_fragment	22	Is_guest_login	36	Dst_host_same_src_prot_rate
9	Urgent	23	Count	37	Dst_host_srv_diff_host_rate
10	Hot	24	Srv_cound	38	Dst_host_ serror_rate
11	Num_failed_logins	25	Serror_rate	39	Dst_host_srv_serror_rate
12	Logged_in	26	Srv_serror_rate	40	Dst_host_rerror_rate
13	Num_compromised	27	Rerror_rate	41	Dst_host_srv_rerror_rate
14	Root_shell	28	Srv_rerror_rate	42	Normal_or_attack

There is a significant difference between the values and data types of each attribute for each original sample in the KDD dataset. In addition, the range of the BP neural network training data and test data should be consistent with the range of the activation function of the neurons in each layer. Also, the input attributes should be numeric values. Therefore, to apply the KDD data to the BP neural network detection model, we need to preprocess the original KDD data samples.

The neural network is trained and tested using the test data, and the experimental results are subsequently compared with the ordinary BP algorithm. The metrics include accuracy, precision, and recall. Accuracy is defined as the ratio of the number of samples correctly classified to the total sample size for a given test set. Precision shows the percentage of positive samples among all reported. The recall rate is for the original sample indicating how many of the positive samples in the sample are correctly predicted.

In this experiment, three layers of the BP neural network are selected, and the number of neuron in each layer is all in the order of 1. The input layer and the hidden layer activation function use a tangent S-type function. Since the number of samples is 42, the number of neurons in the input layer is also 42. If the output results can be judged as intrusion behavior, the number of neurons in the output layer is 1, thus obtaining o = 1. The number of neurons in the hidden layer settings has no normative theoretical guidance. The usual method is based on many experiments to determine the appropriate number of neurons. After the experiment, the hidden layer node is set to 22.

The particle size of the PSO algorithm is determined according to the particle coding and obtain the dimension D = 969. In this paper, the population size N = 30, the maximum velocity of the particle is set to 3, the minimum speed is -3, and the search space of the particle is set to [-1,1]. The velocity and trajectory of the particles depend on the set of learning factors G, O and the inertia weight W, which have great influence on the global search ability and convergence speed of the particle swarm. To ensure better global search ability and local search performance, we set $C_1 = C_2 = 2$ *and w* = 0.7.

V. RESULTS

First, the performance of the PSO algorithm is analyzed by looking at the change tendency of the fitness function of the PSO algorithm for the training data. We used the training data to carry out 50 experiments on the PSO, and the average values were calculated. The results show that the MSE value reaches the minimum value of 0.015 when the PSO algorithm runs in about 150 iterations, which is the optimal particle, and it can be decoded as the initial weight and threshold value of the artificial neural network.

To analyze the performance of the system, ten experiments were carried out. The accuracy results of these two algorithms are shown in Fig. 2, precision results are shown in Fig. 3, and recall results are shown in Fig. 4.
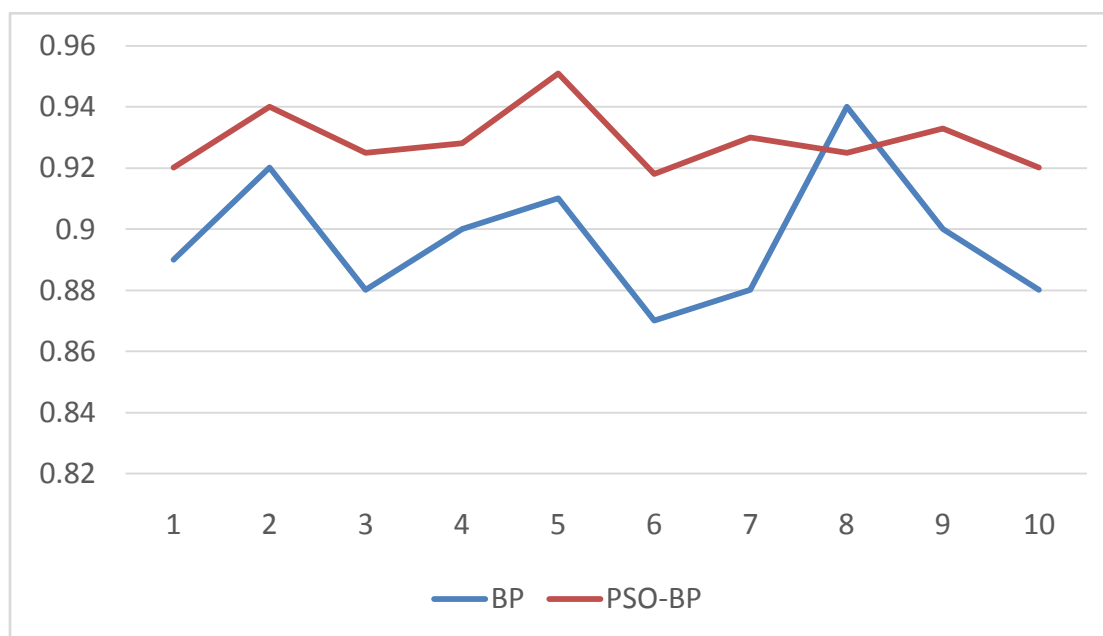
Figure 2. The accuracy of the two algorithms.
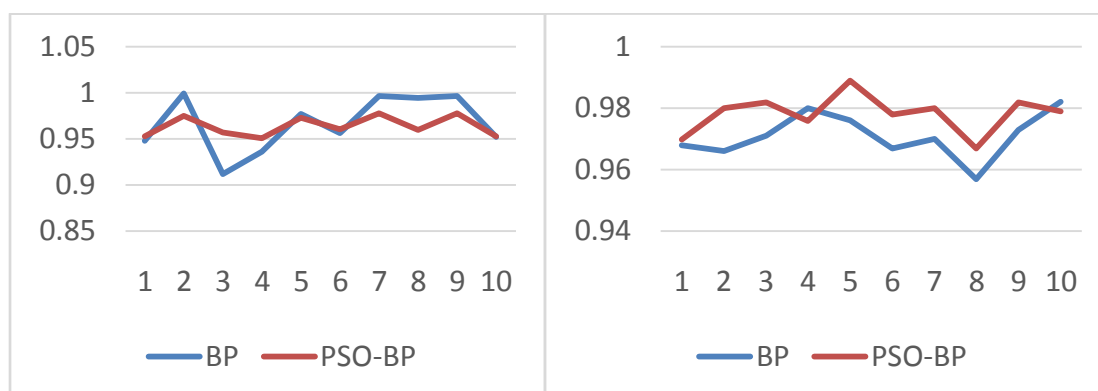
Figure 3. The precision of the two algorithms.
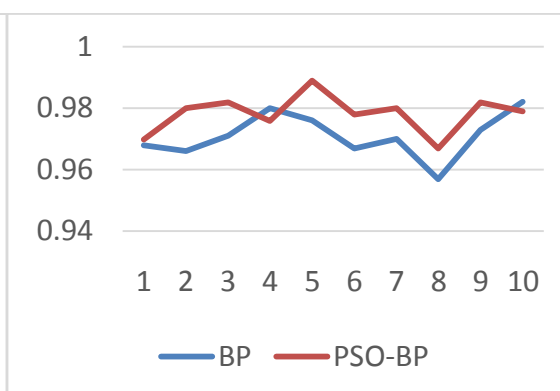
Figure 4. The recall of two algorithms.

As seen from the figures, the accuracy of the PSO-BP algorithm is slightly higher than the pure BP algorithm. First, the momentum factor and the adaptive rate algorithm introduced by the PSO-BP algorithm accelerated the convergence speed of the BP algorithm and avoided falling into a local minimum. Second, the PSO algorithm has a significant advantage in global optimization to enable a more stable precision compared to the traditional BP algorithm. Also, as seen in Figure 4, the recall of the PSO-BP algorithm is slightly better than the traditional BP algorithm.

In summary, the overall detection performance of the proposed PSO-BP detection algorithm is superior to the traditional BP detection algorithm.

VI. CONCLUSION

This paper presents a virtual intrusion detection model based on different types of virtual network structures in KVM. The model is implemented in the KVM network model of a NAT bridge, including the data capture, packet parsing, feature extraction, and neural network detection modules. It is compatible with different network modes in KVM virtualization environments and can capture, process, and analyze the virtual machine communication data flow under different network modes. It provides intrusion detection services for a cloud computing virtualization environment and responds to the attacks of malicious virtual machines.

Aiming at the problem that a BP algorithm is easy to fall into a local minimum [22], this paper proposes an improved BP detection algorithm based on the PSO algorithm, which combines the global search ability of the PSO algorithm and the gradient descent local search of the BP algorithm. The PSO algorithm is introduced to optimize the initial weights and threshold values of the BP algorithm [23]. By using momentum factor and adaptive learning rate method [24], the convergence speed of BP neural network is accelerated and prevented from falling into a local minimum, which improves the detection performance of the algorithm. The experimental results show that the average detection rate of the improved algorithm is higher. It has better detection performance, and can effectively and reliably provide intrusion detection services for cloud computing environments.

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Effects of Kingcure K-11 Hardener and Epoxidized Sunflower Oil on The Properties of Polymer Composite Material Based on Epoxy Resin Gelr 128

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ABSTRACT

Epoxidized sunflower oil (ESO) has been used to toughen epoxy resin GELR 128 cured with an accelerated aliphatic amine curing agent (Kingcure K-11) at room temperature. There was difference in the properties of the polymer composite materials based on epoxy resin GELR 128 cured by Kingcure K-11 between two processes: one-stage process and two-stage process for mixing ESO with epoxy resin GELR 128 at various content of ESO. The results showed that the two-stage process is considered to be more advantageous than the one-stage process. It can be concluded that the impact strength, critical stress intensity factor Kic and decomposition temperature of the polymer composite materials based on epoxy resin GELR 128 cured by Kingcure K-11 with content of ESO 5 phr in two-stage process was greater ones in one-stage process (impact strength: 35.012 kJ/m2, Kic: 2.72 MPa and decomposition temperature: 385.81 0C respectively).

Keywords—*accelerated aliphatic amine curing agent, epoxidized sunflower oil, epoxy resin GELR 128, toughness, two processes, polymer composite materials.*

I. INTRODUCTION

Epoxy resin was used as a glue agent from the mid 20thcentury with special initial properties such as high elasticity, mechanical properties, chemical inertia [1, 2]. However, when epoxy resins are used extensively in other different fields, they are denatured for increased brilliance due to the increased bonding of the polymer molecules [2-4]. This makes epoxy resin easy to peel as well as reduced impact resistance [5]. Nowadays, many research projects is aiming to reduce the brittle strength of epoxy resins, some of them was done by mixing carbon nanotube, oil, liquid rubber particles, or silica

particles, ... [2, 6-11]. Furthermore, materials for these methods are non-renewable. Therefore, methods of using renewable natural resources are one of the best choose that attract the attention of many researchers [12-14]. We also used the vegetable epoxide oil as a blend of epoxy resins to increase the durability and strength of epoxy resins without compromising the modulus and thermal properties of the material.

This study investigated the effect of an accelerated aliphatic amine curing agent (Kingcure K-11) and epoxidized sunflower oil (ESO) on the tensile strength, flexural strength, modulus of elasticity, critical stress intensity factor and thermal property of the polymer composite materials based on epoxy resin GELR 128 in two processes: one-stage process and two-stage process at room temperature.

II. EXPERIMENT

A. Material

- Epoxy resin used in this study was DGEBA supplied by Epoxy Base Electronic Material Corporation Limited of China (GELR 128) which had an epoxide equivalent weight (EEW) of 184-190g eq-1 and a viscosity at 250C: 11-15 Pa.s;

- Epoxidized sunflower oil (ESO) was synthesized by using ion exchange method. The content of epoxy group is 16.45% with oxiran value 6.12.

- Kingcure K-11 (KK1) is an accelerated aliphatic amine curing agent in an amber-colored liquid form was purchased from Sanho Chemical Co.,LTD (Taiwan) (density 1.04 g/cm3 at 250C, viscosity at 250C: 1000-2000 mPa.s, amine value: 430±20 mgKOH/g and Active Hydrogen Equivalent Weight (AHEW): 93).

B. Modified epoxy resins

Modified epoxy resins were prepared by mixing DGEBA GELR 128 and epoxidized sunflower oil in two processes:

One-stage process: the various amount of ESO (0 - 30 phr) was added into 100 g of epoxy resin GELR 128 in 250 ml glass beakers, stirring for 45 minutes. Then KK1 was added with a pre-calculated ratio and stirred for 5 minutes. The all components were poured into a mold for curing at room temperature.

Two-stage process: Mixing ESO and KK1 in a 3-necked 250-well flask were stirred for 15 hours, adding epoxy resin GELR 128 and continued stirring for 5 minutes and then poured the mixture into the mold to cure at room temperature.

C. Research methods

- The morphologies at the fracture surfaces of the epoxy samples were evaluated from Scanning Electron Microscopy (SEM) on Hitachi (Japan) S4800 at the main laboratory, Institute of Materials Science - Vietnam Academy of Science and Technology

- Thermal stability was studied by simultaneous thermos gravimetric analyzer (TGA) by SETARAM TG under a heating rate of 100C/min. within a temperature range of ambient room temperature to 8000C at Hanoi University of Sciences, Hanoi National University.

- The tensile strength was determined according to ISO 527-2012 on the INSTRON 5582-100kN (USA) with the crosshead speed of 2mm/min at the Polymer Centre, Hanoi University of Science and Technology.

- The flexural strength was determined according to ISO 178 on the INSTRON 5528-100kN (USA) with the crosshead speed of 2mm/min at the Polymer Centre, Hanoi University of Science and Technology.

- Izod impact strength was determined according to ISO 180 on the Tinius Olsen Model 92T (USA) at the Polymer Centre, Hanoi University of Science and Technology.

- The critical stress intensity factor, KIC value was determined according to ASTM D5045-99 by three point sidedon a Lloyd 500N (UK) with the crosshead speed of 10mm/min at the Polymer Centre, Hanoi University of Science and Technology.

III. RESULTS

A. Morphological structure

Scanning electron microscopy of modified epoxy resin GELR 128 without ESO and with 15, 20 phr ESO are shown in Figure 1. From Figure 1 (a), the unmodified epoxy resin GELR 128 has smooth surface as a mirror with cracks in different surfaces characterize which is the lower impact strengths of thermoplastic resins. The fractured surface of the modified ESO epoxy resin GELR 128 consists of two distinct phases: spherical resins dispersed in a continuous epoxy network. The seeds are about 1-2 μm in diameter. KK1 is a polyamine that interacts with epoxy resin GELR-128 higher than ESO's epoxy group so that it forms a durable grid while epoxy sunflower oil decomposes into second phase as small liquid droplets (Figure 1b). The surface of epoxy resin GELR 128 with added ESO has an uneven roughness profile as unmolded epoxy resin GELR 128, which shows the durability of the material. For the two-stage process the appearance of seeds which show an fluctuate surface on the broken area (Fig 1c)
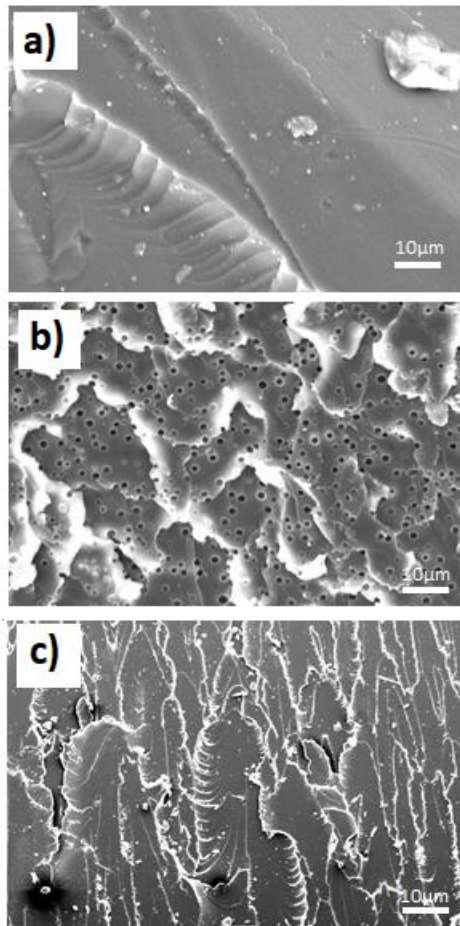

Figure 1SEM images of modified epoxy resin GELR 128 a) without ESO b) one- stage process with 15 phr ESO c) two-stage process with 20 phr ESO

B. Mechanical properties

The results of tensile and flexural properties of epoxy resin GELR 128 were denominated in two processes with and without epoxidized sunflower oil as shown in Table 1. The tensile strength of epoxy resin GELR-128 without ESO is 63.08 MPa with high flexural strength (103.4 MPa) and low modulus (2.94 GPa) which showed the hardness and brilliance of epoxy resin. When ESO is added, tensile strength and flexural strength decrease in proportion to the increase in the amount of ESO in the one-stage process. Phase separation also does not affect the reduction of tensile strength and flexural strength in the two-stage process due to the presence of low modulus phases in the epoxy network. This suggests that epoxy resin GELR 128 with ESO is more resilient than epoxy resin GELR 128 without the addition of a modified substance. In both process, tensile strength decreases gradually as increase the amount of ESO from 10-30 phr. This trend is similar to the flexural strength value, but

this significant decline occurs when ESO content is higher than 5 phr. Comparing with the one-stage process, the mechanical values of the epoxy resin GELR 128 after the denaturation by two-stage process are always lower, proving the superiority of the two-stage process, the material after the modify is more toughness with less amount of denaturation.

The relationship between the amount of ESO content and impact strength is shown in Figure 2. The impact strength of the epoxy resin GELR 128 after denaturation with ESO in two-stage process was significantly higher than one-stage process. However, the impact strength of the epoxy resin GELR 128 was made by one-stage process which is only moderately increased due to single-phase morphology (as SEM image results) which is the same trend in two-stage process. Therefore, the impact resistance value in two-stage process is always higher than one-stage process with all amount of ESO content. The maximum impact strength at ESO content is 5-10 phr and slightly decreases as ESO content increases

Table 1The effect of ESO to the tensile and flexural properties of epoxy resin GELR 128

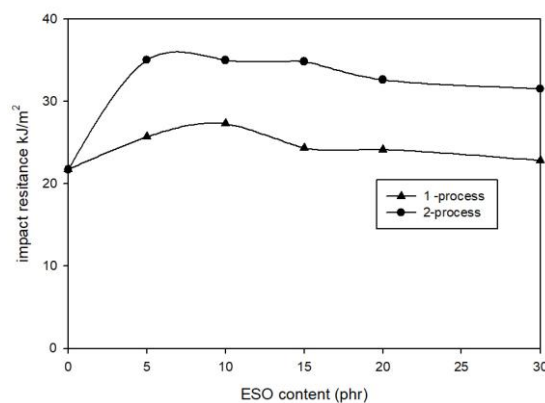|	ESO (phr)	Tensile strength (MPa)	Elastic modular (GPa)	Flexural strength (MPa)	Flexural modular (GPa)
	0	63.08	1.71	103.4	2.94
One-stage process	5	53.48	1.58	94.5	2.62
	10	44.77	1.34	73.2	2.08
	15	38.25	1.33	67.5	1.86
	20	33.91	1.19	45.1	1.47
	30	33.39	1.06	44.2	1.33
Two-stage process	5	52.17	1.54	71.9	2.12
	10	43.20	1.29	62.3	1.87
	15	36.08	1.14	46.3	1.40
	20	27.19	0.98	39.2	1.27
	30	19.53	0.95	28.5	1.19

Figure 2: Impact strength of epoxy resin GELR 128 after denaturation at different content of ESO

The change in the durability deterioration was characteristic by the KIC-concentrated stress ratio by ESO content is shown in Figure 3. It can be seen that the addition of ESO to the epoxy resin GELR 128 which is increased the stress concentrate coefficient. From Figure 3, in the two-stage process, the stress ratio was higher than this in the one-stage process when the content of ESO is 5phr and reached the highest value of 2.58 MPa.m1/2 at the ESO level of 15 phr. Then it is tending to change the same strength but the Kic value in two-stage process is lower than Kic value in one-stage process. So the optimum content of ESO is 5phr. This is explained by the fact that the amount of epoxidised sunflower oil increases, the agglomeration of the oil particles occurs and this causes the material to lose its elongation.
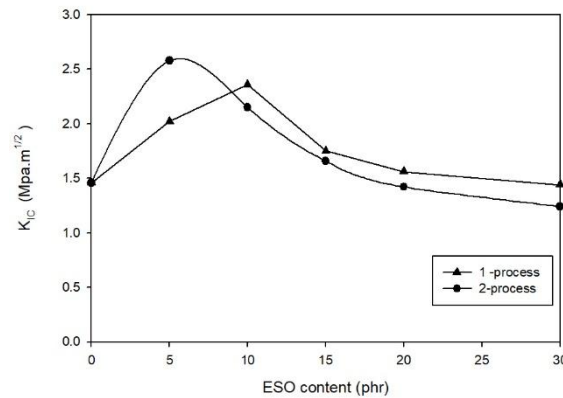
Figure 3Stress concentrate coefficient KIC of epoxy resin GELR 128 after modification at various ESO content

From the previous survey results, epoxy resin GELR 128 with curing by polyamine show the promised properties with the low content of nature oil. Our results show that the content of ESO 5phr was chosen as the suitable ratio to improve the mechanical properties of epoxy resin GELR 128

C. The thermal properties
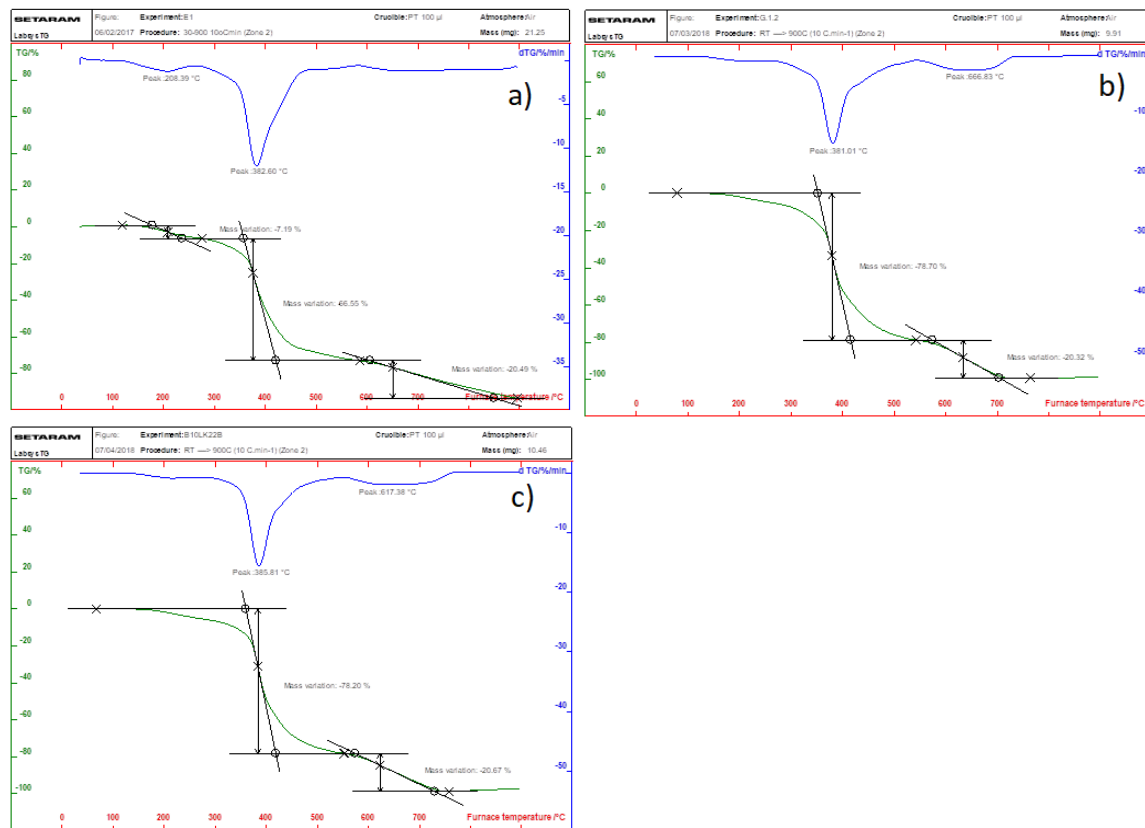
Figure 4The TGA of a) epoxy resin GELR 128, epoxy resin GELR 128 modified with ESO by b) one-stage process, c) two-stage process.

From the results of TGA (table 2 and figure 4), the opposite strength shows which are decrease the maximum decomposition temperature in one-stage process and increase in two-stage process compare with the neat epoxy resin GELR 128 sample. It can conclude that in two-stage process the reaction reach higher yield than in one-stage process In other way, compare with the SEM image (Fig 1), the content of the oil drop in one-stage process made the decompose temperature lower.

Table 2Effect of ESO content on the maximum decomposition (MDT) temperature of epoxy resin GELR 128

Number	ESO content (phr)	MDT, ^{o}C
1	0	382.6
2	10 (one-stage process)	381.01
3	5 (two-stage process)	385.81

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IV. CONCLUSION

The results of the toughen epoxy resin GELR 128 with epoxidized sunflower oil (ESO) cured by an accelerated aliphatic amine curing agent (Kingcure K-11) have shown some promised results. The two-stage process is considered to be more better than one-stage process in tough epoxy resin GELR 128. The impact strength, critical stress intensity factor Kic and decomposition temperature of the polymer composite materials based on epoxy resin GELR 128 cured by Kingcure K-11 with content of ESO 5 phr in two-stage process was greater ones in one-stage process

ACKNOWLEDGMENT

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Prediction of Poultry Yield Using Data Mining Techniques

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ABSTRACT

A poultry yield prediction model have then designed using a data mining and machine learning technique called Classification and Regression Tree (CART) algorithm. The developed model has been optimized and pruned using the Reduced Error Pruning (REP) algorithm to improve prediction accuracy. An algorithm to make the prediction model flexible and capable of making predictions irrespective of poultry size or population has been proposed. The model can be used by poultry farmers to predict yield even before a breeding season. The model can also be used to help farmers take decisions to ensure desirable yield at the end of the breeding season.

Keywords: Datamining; Prediction; Poultry yield, Cart Algorithm

I.   INTRODUCTION

Over the years, pattern extraction from data has evolved from manual to automated processing. Early pattern extraction methods includes Bayes' theorem from the 1700s to regression analysis in the 1800s. The revolution of technology especially computer technology has brought about increase in large data storage, collection and manipulation hence the need for methods and techniques to efficiently discover patterns in these large data (Mucherino*et al.*, 2009). The need for data exploration and extraction later brought about discoveries in Computer Science such as cluster analysis, neural networks, genetic algorithms, decision rules, decision trees and support vector machines; all of which constitute methods of data mining (Han *et al.,* 2011). Data mining is therefore the process of exploring large data sets so as to find purposeful patterns, relationships, correlations or associations within the data sets (Klosgen and Zytkow 2002). It forms the intersection linking various disciplines such as computer science, statistics, machine learning and database systems (Bozdogan, 2003). The main objective of data mining is to convert meaningless data to meaning information which results to knowledge discovery (Sumathi and Sivanandam, 2006). Data mining goes beyond just analyzing raw data. It involves establishment of practices and policies that manage full data life cycle of an organization or enterprise. Data mining also involves building of models and deduction of inference (Han *et al.,* 2011). This means that data mining goes beyond the mere extraction (mining) of data but the extraction of patterns from data to produce knowledge. One attribute data mining and database share is the storing, manipulation and extraction of data.

Data is collected and stored (database). The data is then worked upon (data mining) which results in knowledge discovery. The discovered knowledge can then be stored for further use (database). Different terms have been used to reference data mining. Terms such as: data archaeology, information harvesting, information discovery, knowledge extraction and so on. Gregory Piatetsky-Shapiro invented the term "knowledge discovery in databases" (KDD) in 1989. However, because of the popularity of the term —data mining‖ in machine learning and artificial intelligence (AI) community, the terms KDD and data mining have been used interchangeably (Piatetsky-Shapiro *et al.,* 2011). In general, data mining encompasses six common types of tasks. They are anomaly detection, association rule learning, clustering, classification, regression and summarization (Thuraisingham, 1998). Data are basically mined to achieve one or more of these tasks. Data mining in agriculture is a recent research field (Ramesh and Vardhan, 2013). It is also considered as the future of agriculture (ElFangary, 2009). This forms the basic motivation behind this research. Thus far, some data mining applications in agriculture include: detection of diseases from animal sounds, predicting crop yield, weather and soil types forecasting, etc.

Poultry Farming in Nigeria

Poultry can simply be defined as domesticated birds reared for meat, egg and feather purposes. In Nigeria, poultry is mainly reared for meat and egg purposes. For this reason, the two main poultry breeds reared in Nigeria are broilers (for meat) and layers (for eggs). Other popular poultry breeds in Nigeria include guinea fowls, cockerels, ducks and turkeys. Poultry farming in Nigeria has been on a tremendous rise. This may be attributed to the high rate of unemployment in the country. For some individuals and states, poultry farming has become a means of revenue generation. Nigerians depend heavily on poultry husbandry to create self-employment in a bid to reduce poverty (Heise et al., 2015). Agriculture is a dominant practice in Sub-Saharan Africa countries like Nigeria and is seen as a major instrument for poverty alleviation in the Sub-Saharan region (Larsen et al., 2009). It is therefore important to introduce ideas that will improve poultry husbandry in Nigeria. This research intends to improve poultry farming by developing models that poultry farmers can use to forecast or predict yield using data mining techniques.

Statement of the problem

Prediction of yield or harvest is most farmers' problem. Farmers have often depended on previous experiences to forecast yield but this method most times turns out non-reliable and incorrect (Ramesh and Vardhan, 2013). If farmers can have an idea of what yield will be during the harvest period the farmers take adequate steps or decisions to ensure maximum yield. With data mining, patterns from poultry data that can lead to predictions can be discovered to provide poultry prediction models. The aim of this research work is to develop a prediction model using data mining techniques that can help poultry farmers to predict yield. The objective of the research is to provide local farmers with a tool in form of a model that they can apply to predict yield for upcoming breeding seasons. In the same vein, the model can help poultry farmers navigate through various decision processes as they try to cut costs (cost effective poultry farming).

Justification of Study

Poultry farming in Nigeria has been on a tremendous rise over the past decades. This may be attributed to the high rate of unemployment in the country. For some individuals and states in Nigeria, poultry farming has become a means of revenue generation. Nigerian as a sub-Sahara African country rely on agricultural activities including poultry farming to create self-employment in a bid to reduce poverty (Larsen et al., 2009; Heise et al., 2015). It is therefore important to introduce ideas that will improve poultry farming in Nigeria. The researchers intend to improve poultry farming by developing a model that poultry farmers can use to forecast or predict yield using data mining techniques. Poultry farmers like every other business man (or woman), juggle between opportunity costs, foregoing some needs in favour of others and at the same time, targeting maximum yield as possible. This study is particularly useful as it can help poultry farmers through a number of

permutations of certain factors that affect poultry production and the possible yields that can result from such permutations.

Scope and Limitation

This research is restricted to Adamawa State in particular or the north-eastern region at large. This is because weather factors of Adamawa state have been considered. It has been assumed that weather conditions in other regions of the country differ from the weather conditions in Adamawa state, a north-eastern regional state in Nigeria.

Majority of the data used for the research constitute breeds of broilers and layers with quite a few on turkeys and guinea fowls. Therefore the yield prediction model is not expected to be applicable for birds such as ostriches, pigeons, parrots and so on.

II.   Literature Review

Data Mining Prediction Techniques in Agricultural Research

Clustering algorithm is the technique used to identify appropriate groups of instances in a given set of data (Aggarwal and Reddy, 2014). This algorithm is used when no prior knowledge of the data is available therefore the concept of training or learning data set is practically impossible (Mucherino et al., 2009). A k-means variant (k-means clustering) of the clustering algorithm is among the most popular of the clustering algorithm, ranked among the top 10 algorithm of all the data mining algorithms (Wu et al., 2008). It is therefore no surprise that it has been applied in agricultural research. For example, Urtubia*et al.,* (2007) predicted the problems associated with wine fermentation using the k-means algorithm. The fermentation problem of wine is that the process can be too slow or stagnant (Urtubia*et al.,* 2007; Muchirino*et al.,* 2009). It is therefore important to ensure that the fermentation process concludes smoothly to produce the desired wine quality. To be able to achieve this, metabolites such as organic acid, fructose, glucose, glycerol and ethanol were collected and analysed to obtain data of the fermentation process. The data obtained from the first three days were compared with the data for the whole fermentation process. The k-means algorithm proved that the data for the first 3 days of fermentation was sufficient enough to determine the final outcome of fermentation process. This means that theentire fermentation process can be determined after 3 days and adequate measures can be taken early to improve the wine quality. The K-Nearest Neighbour (K-NN) is another classifier algorithm that works by using the popular principle —birds of a feather move togetherǁ (Mucherino*et al.,* 2009). This algorithm tends to classify instances based on the class of its nearest neighbour (Kotsiantis*et al.,* 2007). Like the K-means clustering algorithm, the K-NN algorithm is also ranked among the top 10 data mining algorithms (Wu *et al.,* 2008).

The K-NN classifier was prescribed as an efficient method for estimating soil water parameter (Mucherino*et al.,* 2009) using crop simulation systems such as CROPSYST (Stockle*et al.,* 1994), DSSAT (Jones *et al.,* 1998) or any crop simulation system. Soil parameters such as the lower limit of plant water availability (LL), the drained upper limit and plant extractable soil water (PESW) are most likely to be unavailable. K-NN algorithm can be used on available information such as soil texture and organic carbon to obtain the unavailable parameters (Mucherino*et al.,* 2009). This shows that K-NN classifier can be used to predict unknown variables from known ones. ElFangary (2009) developed a model for improving cow and buffalo production in Egypt. The research used Pearson's Coefficient to analyse and find correlations between variables such as pregnancy, death, diseases, vaccines and the various interval of the animals' production to develop the model. The Artificial Neural Network (ANN) algorithm is another powerful classifier used for prediction. A typical example of its application was demonstrated by (Kondo *et al.,* 2000) to predict that certain categories of oranges are relatively sweeter by measuring the sugar and acid content of oranges. A three-layer artificial neural network was used to predict that oranges with attributes: reddish color, medium size, low height and glossy appearance are relatively sweeter. Another application of ANN in agriculture was conducted on pigs to detect the presence of diseases via their sounds (Moshou*et al.,* 2001). Initially sound samples of

354 sounds were trained. The sounds consist of coughs from different pigs, metal clanging, grunts, and background noise. Sounds such as cough and metal clanging were difficult to distinguish because they have similar frequency range (Mucherino*et al.*, 2009). The neural network was further trained to distinguish the similar sound. Once that was done, result showed sound recognition correctness greater than 90%.

Similarly, ANN was used to detect watercore in apples (Shahin *et al.,* 2001). Watercore is an interior apple disorder (Mucherino*et al.,* 2009; Herremans, 2014). An ANN was able to identify good apples from bad ones based on their watercore severity. This study was necessary because watercore is an internal disorder and consumers could only discover it after purchase of the apple (Mucherino*et al.,* 2009). The Support Vector Machine (SVM) technique is normally restricted to discriminate between two classes (Mucherino*et al.,*2009; Campilho and Kamel, 2014). Gill *et al.,* (2006) used meteorological and soil moisture to develop SVM predictions for four and seven days forecast of soil moisture. Just like Moshou*et al.,* (2001) research on pigs, Fagerlund (2007) used SVM to distinguish and recognize different bird species based on birds' sounds. Bird sound data were used to train a SVM classifier in conjunction with a binary decision tree. N-fold cross validation was then used to obtain the optimal classifier model that identifies birds.

Crop Yield has been predicted using Multiple Linear Regression (MLR) and Density-Based Clustering Data Mining technique (Ramesh and Vardhan, 2015). Rajeshwari and Arunesh (2016) used three Classification techniques: Naïve Bayes, JRip and J48 (also called C4.5 algorithm) to analyse and predict soil types: red and black. JRip and J48 algorithms are decision tree algorithm proposed by William Cohen and Ross Quinlan respectively. This researcher shows that both decision tree algorithms produced higher prediction accuracy rate compared to the Naïve Bayes technique. JRip and J48 produced 98.18% and 97.27% prediction accuracy while Naïve Bayes technique produced 86.36% prediction accuracy. Chowdhury and Ojha (2017) performed disease diagnosis on mushrooms using Naïve Bayes, Sequential Minimal Optimization (SMO) and Ripple-Down Rule Learner (RIDOR) Classification techniques. They concluded that the Naïve Bayes technique provides better results for mushroom disease diagnosis.

Data Mining Techniques in Poultry Farming
Study shows that very few research have been carried out in poultry farming and production. Thus far, no research has been done to predict poultry production or yield using CART. This constitutes a setback because very little literature is available upon which this research can complement and vice versa. Vale *et al.,* (2008) used decision tree, a prediction tool to estimate mortality rate in broilers when they are exposed to heat wave. The research further strengthens the claim that high temperatures have a negative effect on broilers. Sadeghi *et al.,* (2015) proposed a procedure to distinguish healthy broilers from unhealthy ones based on the sounds they make. The researcher used Fisher Discriminant Analysis (FDA) to classify the healthy broilers from the unhealthy ones. This research is particularly efficient for the early detection of diseases among broilers to enable farmers take appropriate measures.

Comparisons between Various Prediction Techniques
Clustering algorithms are generally easy to implement however, the algorithm require that output classes be identified upfront (Tiwari *et al.,* 2013, Jones, 2015). This is particularly a setback for this research since no prior knowledge of the outcome (yield) of the proposed prediction model is known since yield is as determined by factors such as vaccine, disease, feed and season. Like k-means algorithm, the KNN is relatively easy to implement. It can also be used to classify qualitative and quantitative data attributes (Banks *et al.,* 2011). However, result of the algorithm does not always yield a compact representation of the sample distribution; given room to errors as irrelevant samples will also be equally classified (Elder, 2009). In addition to this setback, the choice of the number of neighbours (K) can produce different results (Banks et al., 2011). Large computational time can also be an issue because the algorithm requires that the distance to every training pattern to be calculated

(de Albornoz and Terashima, 2005). The ANN classifier is a fast learning algorithm which can automatically learn from training dataset. However, the algorithm is hard to interpret and apply to solve real life problems (Braspenning and Thuijsman, 1995; Patan, 2008). We are compelled to feel that this technique might be too complicated for an average farmer to understand and utilise.For SVM, Abe (2005) suggested the following advantages and disadvantages of SVM. The advantages are: strong generalization ability of the dataset provides global optimum solution and robust to outliers. Disadvantages include restriction to two classes thereby making multi-classification problem difficult and extended training time. Poultry yield is a continuous variable not a categorical variable. It therefore doesn't make sense to apply the SVM since the research goal is not to classify yield into two classes but to predict yield.

Decision tree is machine learning and data mining technique that produce models which are easy to interpret and understand (Rokach and Maimon, 2014). This technique is also capable to model variables that have a non-linear relationship with each other (Raut and Nichat, 2017). Decision trees work well with all variable types irrespective of whether it is categorical or continuous or both (Siau, 2008). Decision trees make use of a greedy algorithm which makes it very sensitive to outliers in the training set. In addition to this drawback, the greedy algorithm may result in error predictions at the leaves if an error occurs at corresponding higher level nodes (Rokach and Maimon, 2008). However, to handle the problem of error prediction, large amount of training data sets can be used to train the model (Mitchell, 1977; Aggarwal, 2015). Multiple Linear Regression (MLR) technique is only suitable when the dependent and independent variables share linear relationships (Wendler and Gröttrup, 2016). This implies that situations where no linear relationship exists between some or all of the variables; linear regression techniques (SLR and MLR) are not suitable. The Fisher Discriminant Analysis (FDA) is similar to MLR. It produces fast, direct and concise analytical model solutions which can easily be programmed by IT personnel. It also requires few instances of a dataset to build models. The FDA is however sensitive to outliers, can't handle discrete independent variables or missing values as well as suitable only for linear phenomena (Tuffery, 2011).

After critically assessing these prediction data mining techniques that have been applied in agricultural research, we discover that poultry data works well with decision tree algorithm. This is because decision tree works well with all kinds of data (categorical and continuous data). Decision tree models are also easy to understand and interpret (this is particularly necessary if the model is to be used by local poultry farmers).Vale *et al.* (2008) has also used decision tree to predict broiler mortality rate. This research was however restricted to the impact environmental attributes (environmental temperature) have on broilers. This research did not use key attributes such as: diseases, vaccination, feed type, etc. to predict overall poultry yield.Another similar research for identifying poultry disease based on their sound has been done by Sadeghi *et al.* (2015). While this research is useful for the early detection of diseases among the poultry birds, the research did not provide procedures for predicting overall poultry yield.

III.   Methodology

Research Framework

The first step of building any model is the collection of dataset. Most times, the data are inconsistent and contain errors making the data unfit for implementing the model. To resolve this, the data mining task of anomaly detection called data pre-processing is required (Tan, 2006). The data is then divided into two sets: the training data set and the validation data set. The training data set is used to build the model using the CART algorithm (regression tree) and the validation set is used to optimize the model by pruning it. The post pruning technique known as Reduced Error Pruning (REP) will be applied on the fully grown tree to reduce model overfitting and increase prediction accuracy (Mitchell, 1977). The model is then tested with the validation data set, a process referred to as cross validation. REP and cross validation form part of the pruning process. The pruned tree produces a smaller, précised

prediction tree model which we propose to be the poultry prediction model. These steps have been illustrated diagrammatically in the Figure 1.

CART Algorithm

CART is an umbrella term popularized by Breiman et al., (1984) to describe the similar procedures of both classification trees and regression trees as a decision tree algorithm (Brieman et al, 1984). The CART algorithm follows a procedure called recursive partitioning algorithm that seeks to repeatedly partition a large dataset space into smaller rectangles or subsets aiming to contain as pure as possible, elements of the same class or category (Han et al., 2011; Niu, 2017).Though, classification tree and regression tree algorithms share a common decision tree name known as CART, there is a major difference between both (Aggarwal, 2015). The Classification tree is mainly used to classify categorical attributes / variables while the regression tree on the other hand is used to classify and predict continuous or numeric values (Champandard, 2003). A categorical variable can be viewed as a label or quantity used to represent a class for example: colour (red, green, blue) or age group (young, adult, elderly) and so on. Numeric/continuous variables on the other hand are numbers that can take any value (Hoffmann, 2016). Yield, the target variable to be predicted is a continuous variable. This is the reason why the regression tree algorithm of CART has been chosen to build the prediction model.
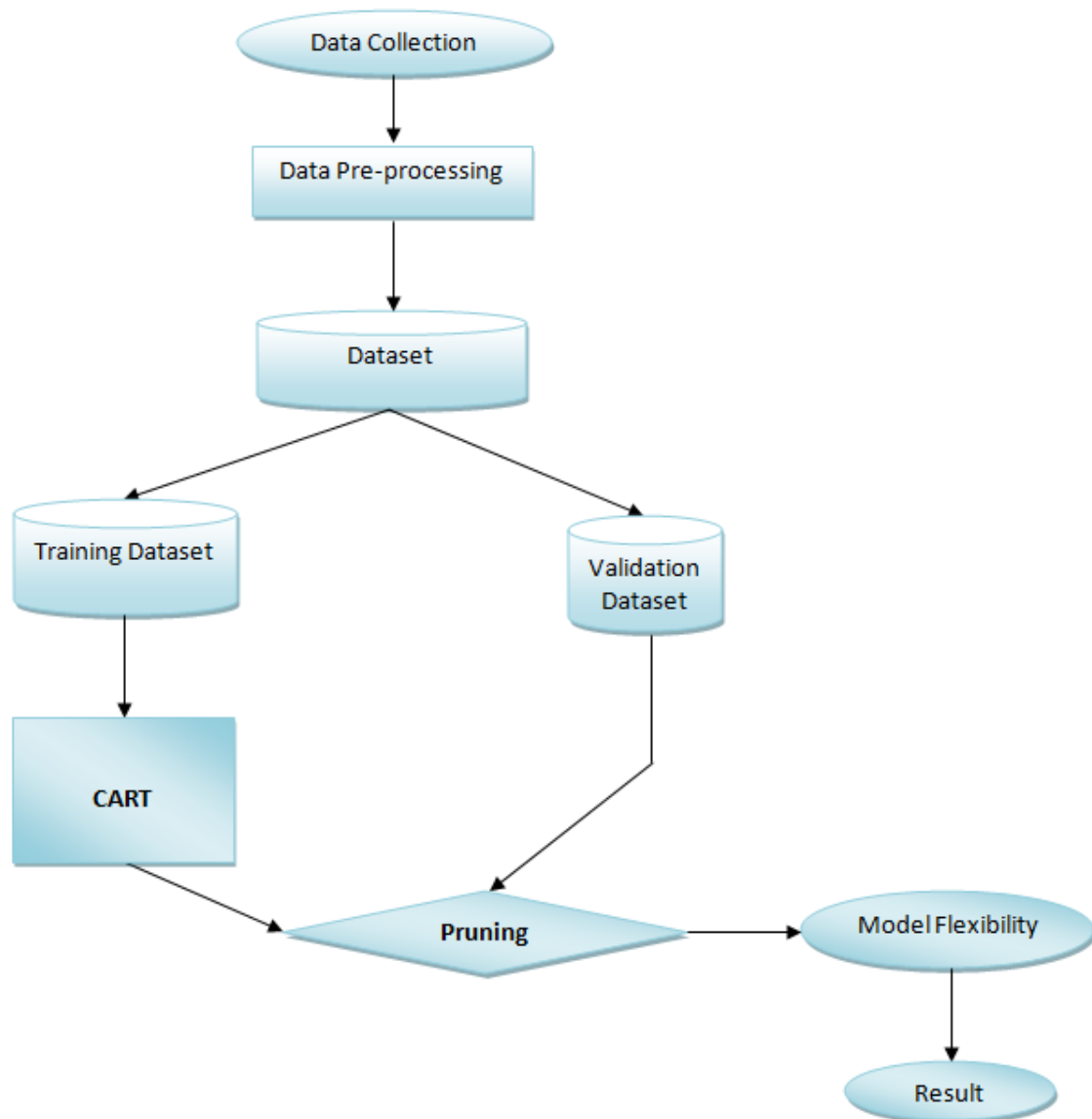

Figure 1: Conceptual framework of the research

Structure of the CART Model

The CART decision tree model consists of nodes, branches and leaves (Wolff et al., 2011; Sucar, 2011; Bhattacharyya and Kalita, 2013). The nodes represent decisions to be taken as one navigates through the tree (Rokach and Maimon, 2005). The model is built in a top-to-bottom manner (Rokach and Maimon, 2005; Wang, 2008; Han et al., 2011). The topmost decision node is called the root decision node while the terminal nodes are called leaves (Beretti et al., 2016).

The branches of the CART model represent paths leading from one decision node to another. The leaves represent the final decisions reached based on prior decision steps taken along corresponding decision paths (Tjoa and Trujillo, 2010).A locally optimized linear model (regression) is formed at the leaves which are the predicted target values (Aggarwal, 2015). The predicted value at the leaf node is usually the average of the values in a particular class after a split (Witten and Eibe, 2005).At each node, starting from the root node, the CART algorithm attempts to asks a —yes‖ or —no‖ (binary) question and an appropriate path is followed either left or right (splitting the node) to subsequent decision nodes down the tree (Mitchell, 1997). The same process is repeated on each node, splitting the nodes continuously (recursive partitioning) until a decision is reached at the leaves (Beretti et al., 2016). Due to the binary splitting of decision nodes in the CART decision tree, CART is essentially a binary tree (Hill et al., 2006; Aggarwal, 2014; Niu, 2017). Figure 2 illustrates the structure of CART.
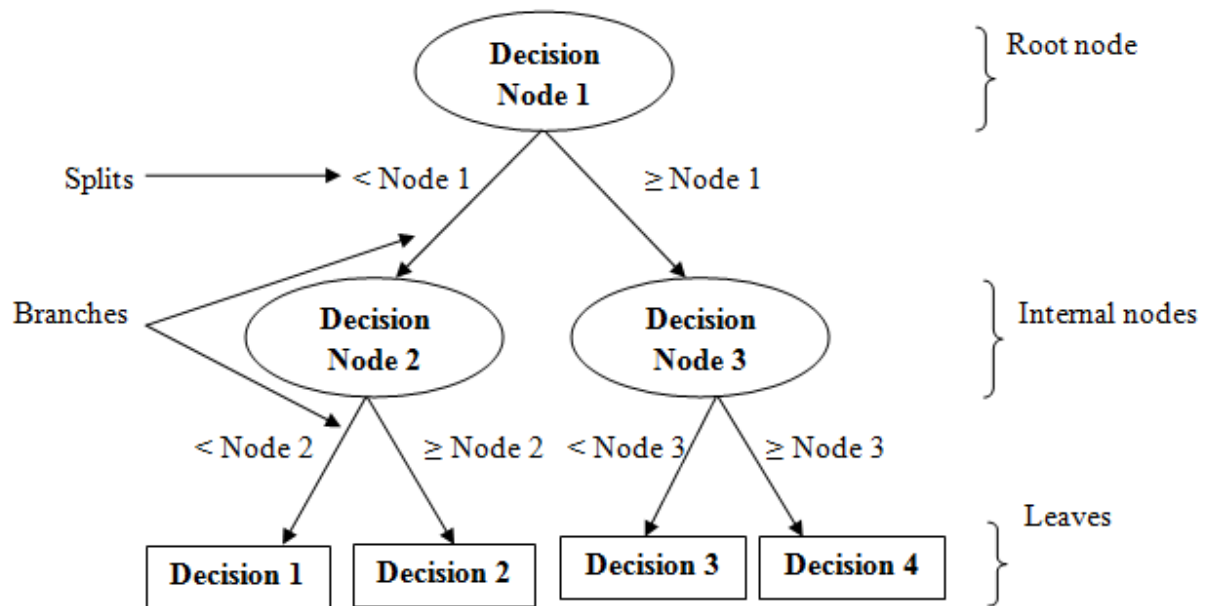

Figure 2: structure of CART

Building the CART Model

Just like every other tree induction algorithm, building a CART model requires some criteria –the splitting criteria, the stopping criteria and pruning criteria (Aggarwal, 2014; Aggarwal, 2015).

Splitting Criteria

To be able to classify similar data at various points in a dataset space, a criterion to determine what attributes of the data to split and the particular point at which the splitting should occur is necessary. That is where the splitting criteria come to play. The splitting criteria of a CART is the measure use to determine the best variable to split as well as the most appropriate points to split the variable so as to achieve classification purity (Diday et al, 2013). Purity in this case is the measure of the homogeneity of elements or attribute in a particular class (Witten and Eibe, 2005; Aggarwal, 2015). If a particular class/node is said to be 100% pure, it means that the class/node consist of 100% similar elements with no error or outlier (dissimilar element/attribute). To achieve pure classification splits, for

classification trees, some splitting criteria have been proposed such as Entropy, Gini index and Twoing (Mitchell, 1997; Wu and Kumar, 2009; Issac and Israr, 2014). For a regression tree model however, a splitting criteria that involves an error based measure or measure of variance is considered more appropriate because of the continuous numerical implication of the attributes of the target variable (Witten and Frank, 2005; Aggarwal, 2015). To classify variables or attributes with respect to a target numeric continuous variable, a locally optimised linear model is obtained from each hierarchical partitioning of the decision node at the leaves of the tree (Aggarwal, 2015). To obtain a true representation of the value of every split, the average of all the values of the split is computed and used (Witten and Frank, 2005; Moolayil, 2016). This is indicated at the leaves of the tree and along decision paths along the tree. One common variant measurement splitting criteria for a regression tree is the Standard Deviation Reduction (SDR) measure (Witten and Frank, 2005; Moolayil, 2016).

Pruning Criteria

Pruning a tree requires cutting off branches from the tree so as to improve accuracy and reduce overfitting (Mitchell, 1997; Witten and Eibe, 2005). Pruning is a way of making complex and large trees simpler and precise. This is in accordance to Occam's razor theory which states that a simpler and less complex a model is, the more accurate it is (Hall et al., 2011).Pruning techniques/criteria that involves the use of a validation dataset are called post pruning techniques. Post pruning requires that a tree model be fully grown from top to bottom and then pruned bottom to top (Aggarwal, 2015). This pruning technique is quite different from the pre pruning technique which requires that the tree be stopped early enough before it begins to over fit (Mitchell, 1997). The problem with pre pruning however is that there is the uncertainty of the _early point' to stop the tree growth (Aggarwal, 2015). Mitchell, (1997) also suggested that growing the tree fully is the most practical approach for tree induction models. For this reason, we decided to use a post pruning technique. Some post-pruning criteria include cost complexity pruning, reduced-error pruning and rule-based pruning (Mitchell, 1997).

Regression Tree Model for Poultry Prediction

For the poultry prediction model, the SDR measure as prescribed by Witten and Frank (2005) will be used. The splitting process continues until no further splitting is feasible (when partitions are as pure as possible). Though this stopping criterion will result to a large tree, it is however the most pragmatic criterion for any tree induction model (Mitchell, 1997). The resulting tree will be pruned using the REP criterion/technique to optimise a regression tree model that will predict the target variable *yield* using the predictor variables *vaccine*, *season, feed*, and *disease* all of which will form decision nodes of the regression tree model.

Training and Validation Dataset

For the purpose of developing algorithms and models for machine learning, a training dataset and validation datasets are required (Hall et al., 2011).CART algorithms generally require a significantly large amount of training dataset (Aggarwal, 2015). Though there isn't any specified percentage of dataset to be set aside as training dataset, certain literatures suggest over 50% of the total dataset. For the purpose of this research, we decide to utilize the first 11-breeding period (55% of the total dataset) for our training dataset while the remaining 9 breeding periods will be used as the validation dataset to prune the regression tree and validate the model as shown in Table 1 and 2.

Table 1: Training dataset

Breeding Period (2006)	Vaccine Administered	Disease Breakout	Season	Feed Type	Yield
1	not enough	high	dry	Low	356
2	Enough	low	dry	Low	352
3	Enough	low	rainy	High	390
4	Enough	low	rainy	Low	384
5	not enough	low	rainy	High	380
6	Enough	low	dry	Low	375
7	not enough	high	rainy	Low	347
8	not enough	high	dry	High	365
9	enough	low	dry	High	375
10	not enough	high	rainy	Low	345
11	enough	low	rainy	High	400

Breeding Period (2006)	Vaccine Administered	Disease Breakout	Season	Feed Type	Yield
12	Enough	High	Rainy	Low fat	387
13	Enough	Low	Dry	High fat	383
14	Not enough	High	Dry	Low fat	350
15	Enough	Low	Dry	Low fat	365
16	Not enough	High	Rainy	High fat	346
17	Not enough	Low	Rainy	High fat	372
18	Not enough	High	Dry	Low fat	347
19	Enough	Low	Dry	High fat	387
20	Enough	Low	Dry	High fat	384

Building the Regression Tree Model

Building a regression tree model using SDR splitting criterion is summarised into the following algorithm/ steps.

Step 1: Calculate the standard deviation of target variable

Step 2: Separate attributes of each predictor variable of the dataset

Step 3: Calculate the standard deviation of variables based on their attributes

Step 4: The standard deviation of target variable before separating predictor variable is separated from resulting standard deviation from step 3 after separating predictor variables

- The result from step 4 is the Standard Deviation Reduction

Step 5: Select variable with the largest/highest SDR as decision node

Step 6: The attributes of selected variable from step 5 is separated

Step 7: Based on the separated attributes of selected variable from 5, calculate SD of attribute sets.

- Attribute set with SD > 0 is split further (go to step 3)

Step 8: Repeat process recursively until all non-leaf variables (decision nodes) are processed

Step 9: For final processed variables with more than one attribute leading to leaf nodes, calculate the average as the final value for the leaf node (target value).

Reduced-Error Pruning (REP)

The reduced-error pruning (by Quinlan 1987) is a post pruning technique done bottom to top (Mitchell, 1997). This technique views every decision node in the tree as a pruning candidate. It involves replacing a set of decision nodes with the most common classification and assigning it to affiliate leafs

(Mitchell, 1997). The replacement is done only if the resulting pruned tree supports the validation dataset. This is because classifications irregularities that may occur with the training dataset are unlikely to occur with the validation dataset (Mitchell, 1997). The reduced-error pruning technique is been used in this research because of its simplicity and speed (Mitchell, 1997).

REP algorithm/steps are given as:

Step 1: Break full tree into sub trees

Step 2: Prune each sub tree by replacing the decision node with the most common decision node to form a pruned tree

Step 3: Test pruned tree against validation dataset

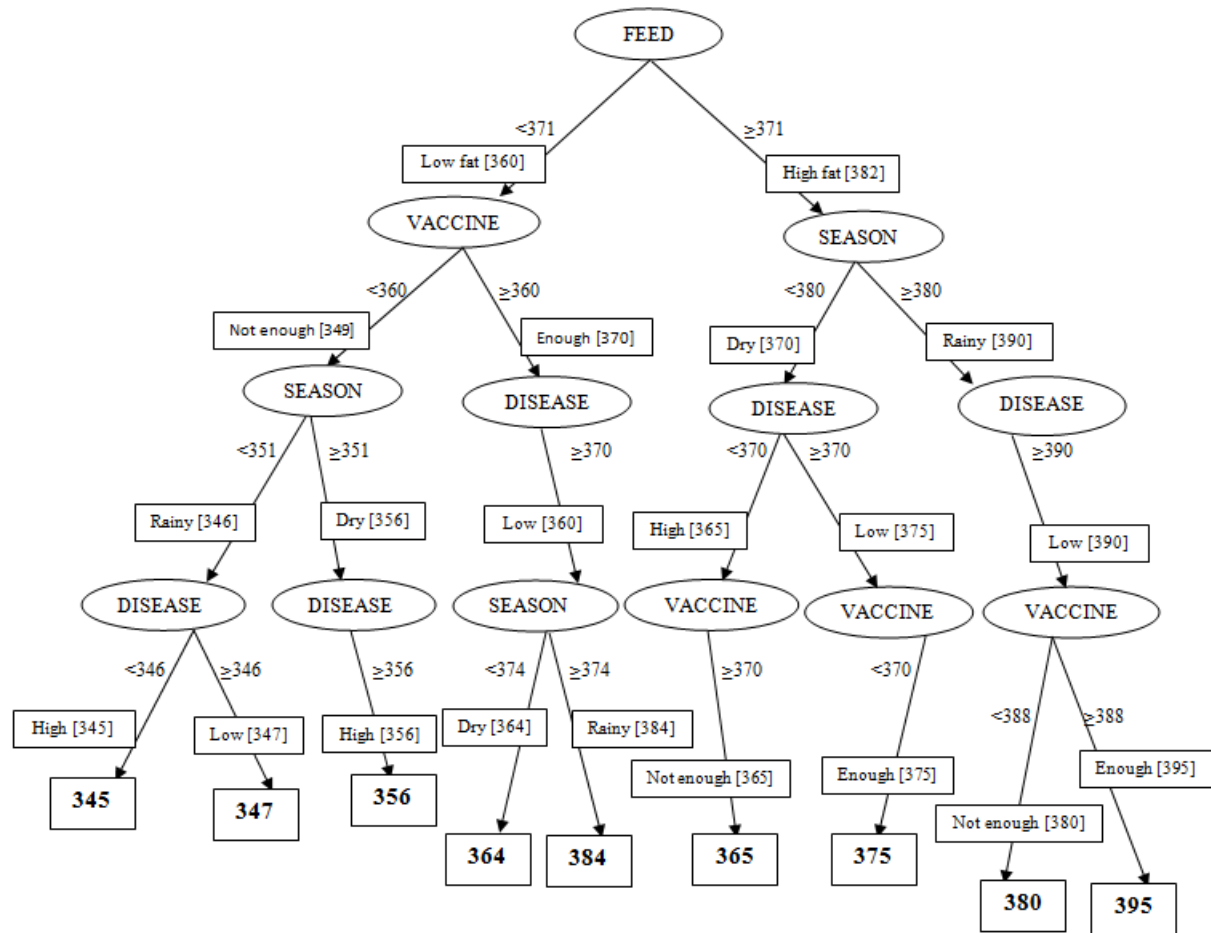Step 4: Select pruned sub tree with the least classification error.

Figure 3: Complete regression tree

Pruning the Regression Tree

Pruning is required to reduce overfitting. Pruning is also a concept supported by Occam's theory which states that the smaller a model, the more accurate it is (Hall et al., 2011). We begin the REP technique as prescribe by Mitchell (1997) by dividing the tree into two sub trees: sub tree A and sub tree B as shown in Figure 4.1. Two pruned regression tree have been obtained (see Figures 4.2).
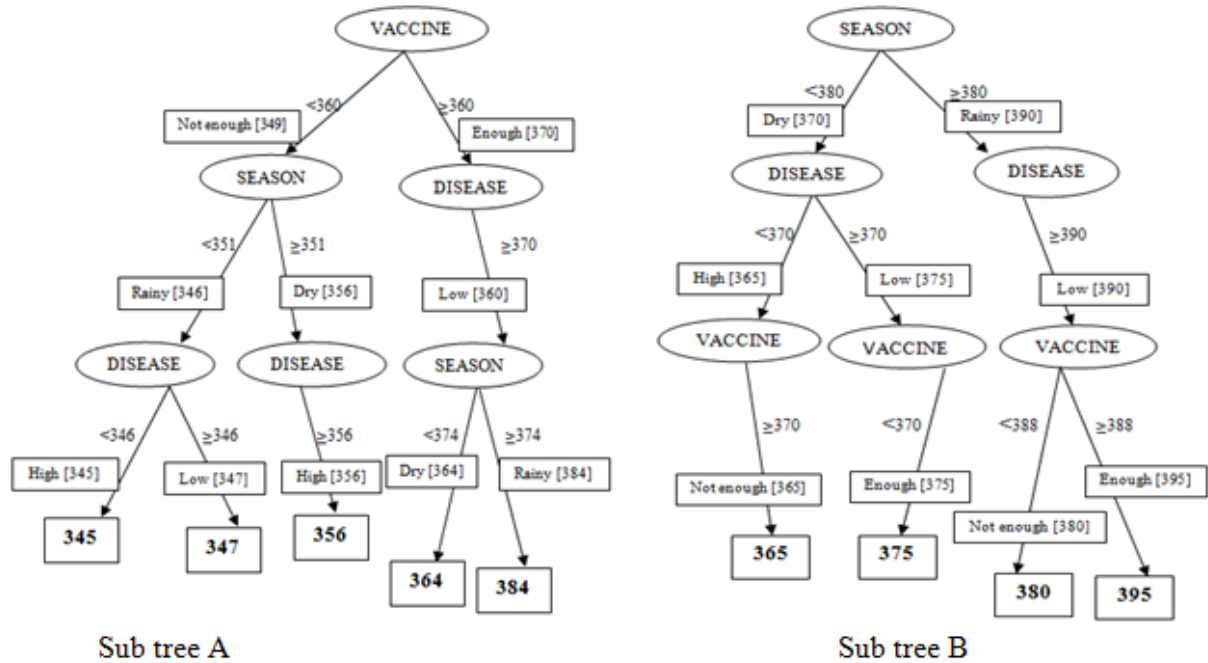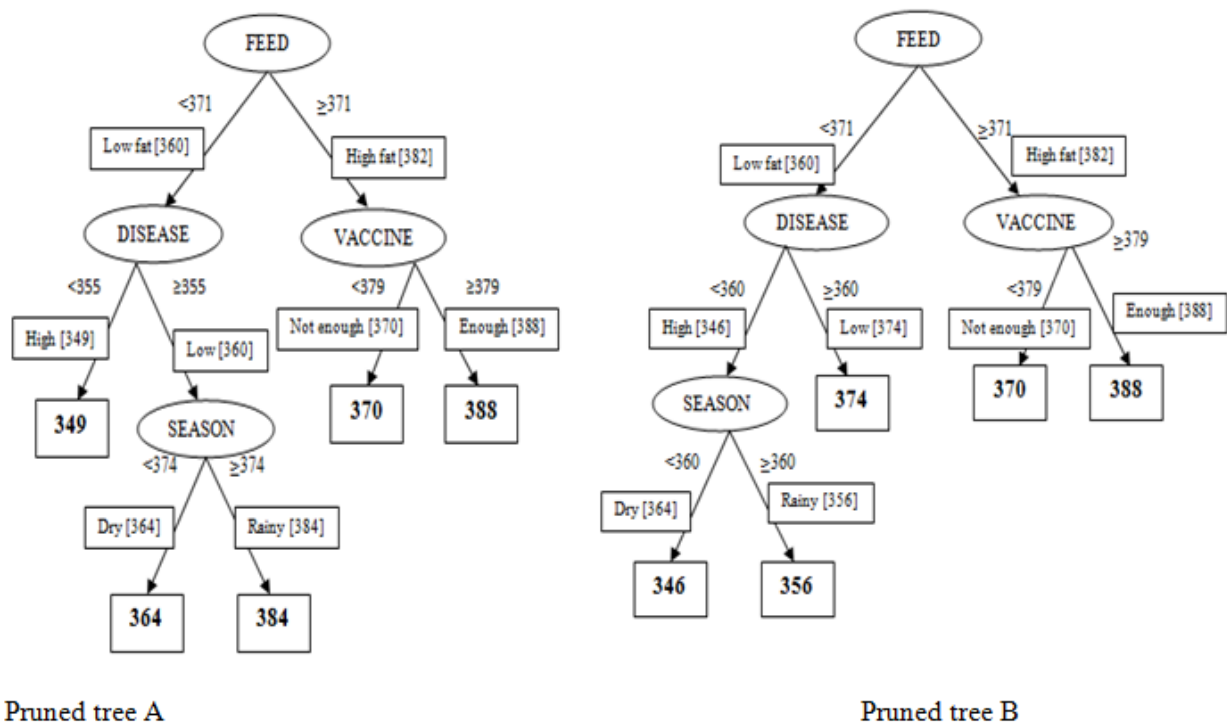
Figure 4.1: Sub trees A and B

Figure 4.2: Pruned tree A and B

Cross Validation

The variables of the validation data set have been rearranged in the same pattern as the pruned tree. Misclassified classes of pruned trees A and B have been indicated with bold italics as shown in Table 2 and Table 3 respectively.

Table 2: Misclassification table of pruned tree A

Breeding Period (2006)	Feed Type	Vaccine Administered	Disease Breakout	Season	Yield
13	High fat	Enough	Low	Dry	383
16	*High fat*	*Not enough*	*High*	*Rainy*	*346*
17	High fat	Not enough	Low	Rainy	372
19	High fat	Enough	Low	Dry	387
20	High fat	Enough	Low	Dry	384
12	*Low fat*	*Enough*	*High*	*Rainy*	*387*
14	Low fat	Not enough	High	Dry	350
15	*Low fat*	*Enough*	*Low*	*Dry*	*365*
18	Low fat	Not enough	High	Dry	347

Table 3: Misclassification table of pruned tree B

Breeding Period (2006)	Feed Type	Vaccine Administered	Disease Breakout	Season	Yield
13	High fat	Enough	Low	Dry	383
16	*High fat*	*Not enough*	*High*	*Rainy*	*346*
17	High fat	Not enough	Low	Rainy	372
19	High fat	Enough	Low	Dry	387
20	High fat	Enough	Low	Dry	384
12	*Low fat*	*Enough*	*High*	*Rainy*	*387*
14	Low fat	Not enough	High	Dry	350
15	Low fat	Enough	Low	Dry	365
18	Low fat	Not enough	High	Dry	347

We propose that pruned tree B be our selected model for predicting poultry yield. Pruned tree B has been selected because of it contains less classification errors (22%, indicated in bold italics) compared to pruned tree A (33%, also indicated in bold italics).

Applying the Prediction Model to Predict Poultry Yield
The main objective of this research is to develop a model that poultry farmers can use to predict poultry yield. A regression tree model has been developed in that respect. However, it is necessary to present this model in such a way that the local poultry farmers irrespective of the population size of their respective poultry farms can apply and utilize.
The CART algorithm has been applied on a sample size of 400 poultry birds to demonstrate how we can develop a prediction model. As a result, the predicted yields have been with respect to a population size of 400 poultry birds. The issue of a non-flexible model therefore arises. We present a simple algorithm to modify the developed model such that the model makes percentile prediction. This way, predictions can be achieved by simply multiplying the percentile prediction with whatever poultry sample size. The algorithm has been presented below.

Algorithm

Poultry percentile prediction model, regression tree, N

N = sample population

If Feed = Feed $_{high\ fat}$ then

$$\text{Vaccine }_{not\ enough} = \frac{[\frac{370*100}{400}]}{100} * N$$

$$\text{Vaccine }_{enough} = \frac{[\frac{388*100}{400}]}{100} * N$$

Else if

Feed = Feed $_{low\ fat}$ then

$$\text{Disease }_{low} = \frac{[\frac{374*100}{400}]}{100} * N$$

Else if

Disease = Disease $_{high}$ then

$$\text{Season }_{dry} = \frac{[\frac{346*100}{400}]}{100} * N$$

$$\text{Season }_{rainy} = \frac{[\frac{356*100}{400}]}{100} * N$$
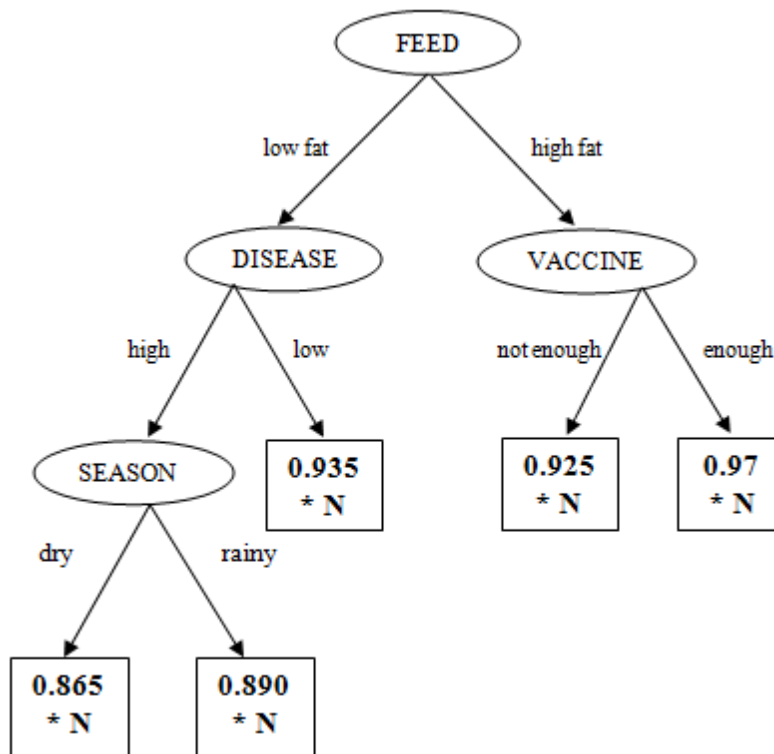
End if

End.

The output is shown in Figure 5.

Figure 5: Percentile prediction model

IV.   Conclusion

Data mining techniques generally unravel hidden patterns in data. Knowledge can be discovered from this hidden pattern. Poultry data have been collected and mined in this research and patterns which can result in yield prediction have been discovered using regression tree of the CART algorithm. To achieve this, we employed the SDR technique to hierarchically split the data rather than other splitting techniques like Gini index and entropy because of the numerical and continuous implication of the target variable _Yield'.To avoid model over fitting and improve accuracy of the model, a post pruning technique called REP have been used. In line with post pruning techniques, a validation data set was set aside to test the performance of two pruned model trees. The model tree that performed better with the validation data set was chosen as our proposed prediction model.To make the proposed model flexible, we presented another algorithm that converts predictions into percentiles based on the predictions of the proposed model. This algorithm makes prediction for whatever poultry population by multiplying the resulting predictions at the leaf nodes with the poultry population (N). CART algorithms have been applied for prediction purposes with high prediction accuracy. This can largely be attributed to the fact that CART is a machine learning algorithm that is well grounded in rigorous statistics and probability theory (Wu and Kumar, 2009). A CART model for predicting poultry yield has been developed in this study and it has been pruned to provide optimal results.

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Measuring the facility of use of a website designed with a methodology based on concepts of design of ontologies

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ABSTRACT

Acceptance of a website is determined by various factors, one of the most important is the organization that allows users to access to functions, resources and information that it contains. This work consisted of a study of comparative usability between a website designed using principles of linguistics and design of ontologies and other using a strategy of a commercial product. A plan was designed and applied to evaluate the following aspects of website: ease of use, efficiency to access its information, efficacy to perform tasks and user satisfaction. Heuristic and user tests were used as diagnostic tools in usability evaluations, and an observation guide was made by an external evaluator as a complement to previous tests. The results clearly shown that is better use the proposed website design methodology. This allows to create site more structured, functional and with greater ease of access to resources that it contain.

Keywords—*Ontology, heuristic tests, usability, websites*

I. INTRODUCTION

Design of website includes various stages that involve: technical development, information structure and visual design [1]. As any artifact used by humans, the design requires an architecture that is well structured, organized, functional and useful content; and that it involves from its conception usability. This is an attribute of quality that measures ease of use in user interfaces (IU) [2].

This work describes a study of usability comparative; this is oriented at end users of a website designed based on a methodology adapted based on design of ontologies [3] against a site designs with a commercial product strategy [4].

II. DESCRIPTION OF PROBLEM

In a previous work [3], it was evaluated the usability of structure of a website planned with a methodology adapted to be assimilates more easily by designers. The results obtained confirmed a better understanding of the designers in their interaction with website structure, and improvements in aspectsas efficacy, efficiency and subjective satisfaction. As next stage, it is necessary to contrast the degree of usability from end users'point of viewof a website of the proposed methodology against the design of commercial option, to identify advances in ease and simplicity of use, efficiency and effectiveness in access to information, to obtain a satisfactory experience of users with website designed with our proposed methodology.

III. SOLUTION PROPOSAL

A plan was designed and implemented to evaluate the usability of website design, using user test as known as Test of Guerrilla [5]; and with this determines issues in usage and interaction of users with the website interface. Evaluation instruments consisted of usability heuristics, [6], observation guide and usability metrics supported by: [7], [8][9], [5], [10], [11], [12], [13][14],[15], [16].

Previously to this study, two websites were designed (figure 1), these design with different methodologies [3] and [4]. To avoid certain slant with final results, both designs were implemented using Adobe Dreamweaver CS5 and HTML.

Schoolwebsite Adapted Methodology Design web structure base on ontologies	Schoolwebsite Alternative web design
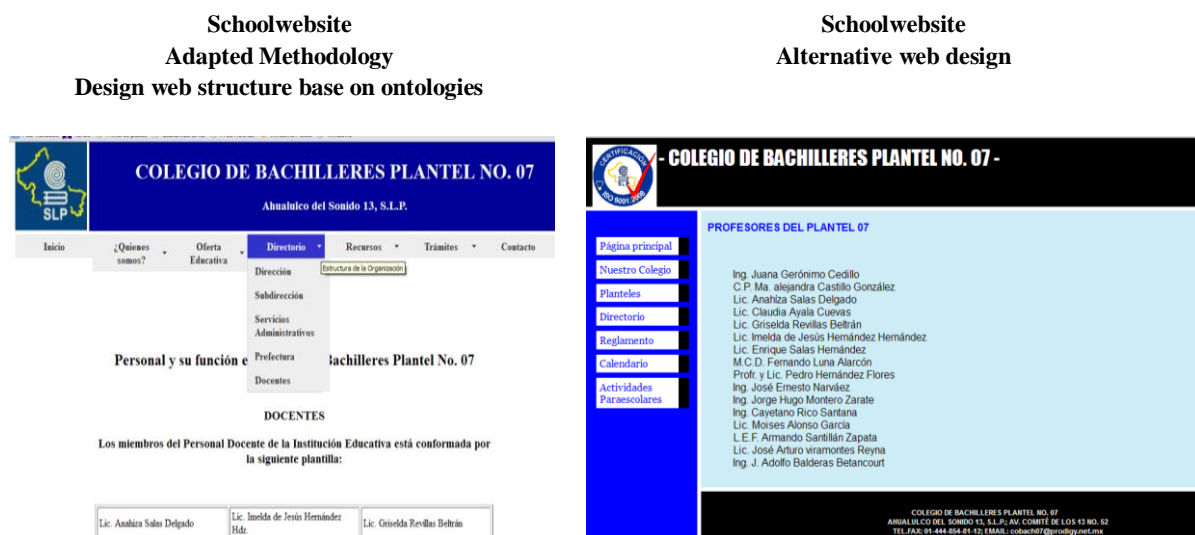
Fig. 1.   School websites used in tests

A.   Evaluation of the usability of website design applying user test

Environment in which the test were made is described below, description of end users is shown in table I, material used is shown in table II and photography of interference and distractions-free spaces that were used are shown in figure 2:

TABLE I.   GENERAL INFORMATION OF THE GROUP OF EVALUATION OF THE USABILITY OF WEBSITE

General data on participant group	Description
Test date	From 20 Aprilto 2 May 2017
Place where the test is performed	Faculty of Engineering of the UASLP, México
Type of participants	Students
Age	From19 to 21 yearsold
Gender	6 women, 4 men
Participants with experience in web design	2 women, 3 men

TABLE II.   MATERIAL AND THE EQUIPMENT USED IN THE USABILITY TEST OF WEBSITE

Equipment	3 laptops Hewlett Packard with operating system Windows 7

Material	Internet browser: Internet Explorer, Mozilla Firefox and Google Chrome Projector Epson Power Lite S6+
	Electronic and printed document of exercises of No. 3 practical Case Electronicand printed document of the evaluation questionnaire Printed document of the observation guide

Fig. 2.   Mechatronics Laboratory of the Faculty of Engineering of Autonomy University of San Luis Potosi.

B.   Execution user test to evaluate the usability of website

Previously, tasks to be performed by users were designed for usability test of website, grouping these in next three steps:

Step 1: Provide to users specific instructions from their tasks to be performed, using an electronic and printeddocument. This was refined from a draft handbook used in a previous usability study [3].

Step 2: The users were instructed in the tasks to be executed when they accessing website, and information that they should get when they were interacting with web interface; also, it was explained to them how register information about realization of their tasks; and how to use base 7Likert questionnairetrying to avoid in results a possible bias. Treatment of the users were with respect and kindness, gaining their confidence so that they would be willing to expose in a written or verbal form their doubts, observations and comments. As result, users weremore active and more enthusiastic when they were resolving the tests. Each interaction of them with website provided relevant and timely information.

Step 3: During the development of the user's test, an evaluator applied two instruments to the users: a questionnaire to check the usability of website and an observation guide to determine performance and interaction of them when using the web interface (figure 3).
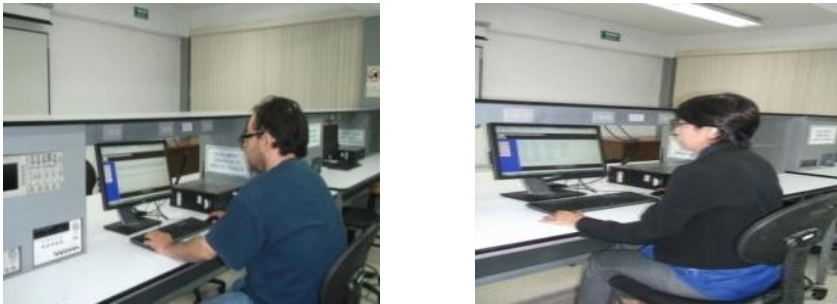

Fig. 3.   User and evaluator during the usability testing of website

C. Exercises and results of usability evaluation of website applying user's test

Exercises and results of the user's test are described in detail below:

Exercise 1: The users interacted and navigated through interface of School website to familiarize with it. This exercise was important to achieve next tasks.

Exercise 2: The users navigate through the website, to search information about the personnel that work in this institution, he selected in his interaction with website an element (a relationship found) and returned to the main concept.

Exercise 3: The users navigated through the website and found links on the different proceedings of institution. He recorded at least two procedures in the format provided and returned to home page.

Exercise 4: The user in his interaction and navigation through website, found concepts that make up infrastructure of school website. He documented at least two elements related to this task and returned to the start point.

Exercise 5: The user agreed and interacted with website to search and find information about the educational offer, careers or training offered by institution.

General results derived from user's test exercises are described in figure 4, this shows the percentage of completed tasks.
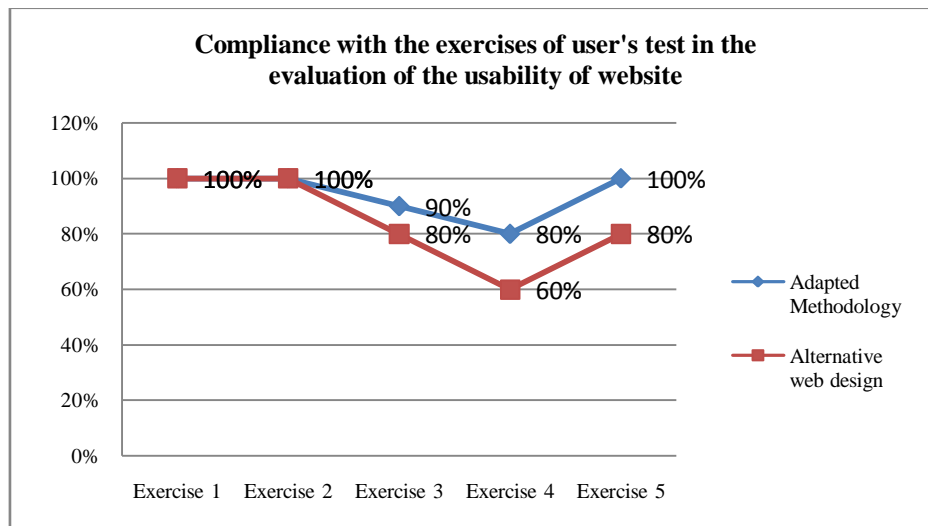

Fig. 4. Compliance of exercises of user's test in the evaluation of the usability of websites

In figure 5, overall average of clicks that users gave during performance of user's test exercises is displayed.
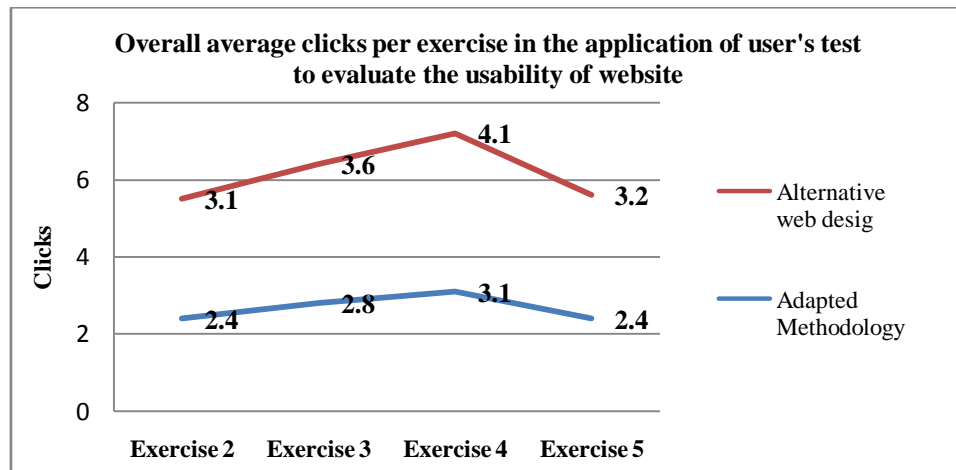
Overall average clicks per exercise in the application of user's test to evaluate the usability of website

Fig. 5. Overall average clicks per exercise

After of test´s end, users answered questionnaire (using Liker-7 scale), and their results are described in table III. The global average represents the degree of subjective satisfaction of users to perform the exercises of user's test in their interaction with websites.

TABLE III.   OVERALL RESULTS OF THE SUBJECTIVE SATISFACTION OF USERS WITH RESPECT TO THE DESIGN OF WEBSITE

Usabilityaspects	% Global average AdaptedMethodology	% Global average Alternative web design
Consistency	93.6 %	85.7 %
User' control	92.2 %	82.2 %
Visual presentation	92.9 %	84.3 %
Handling and recovery from errors	92.9 %	78.6 %
Reducingmemory load	91.4 %	85.0 %
Overallsatisfaction	91.1 %	80.7 %
Guide and help	91.4 %	75.7 %
Usingrelationships	90.0 %	86.5 %
Generalaverage	91.94 %	82.34 %

The comments of users highlight the ease of navigation to access contents and elements that structure both sites designs, however, results of subjective satisfaction questionnaire demonstrate (table III) that users expressed greater pleasure towards ease of use and functionality of the website designed with the adapted methodology, considering that this was useful and helped them to complete their tasks more quickly and fewer clicks.

D.   Usability evaluation results of website using an observation guide

In the development of usability test, an evaluator estimated and recorded data obtained by users when performing the user test exercises. Geometric mean was chosen to resume usability metrics derived from the calculation of each one of aspects and attributes evaluate in the tests (Table IV).

TABLE IV.   GLOBAL RESULTS IN THE EVALUATION OF METRICS AND USABILITY ASPECTSOF WEBSITE,

UsabilityMetrics	Attributes * Time measured in minutes (min.)	Geometric mean per aspect		Percentage	
		Adapted methodology base on ontologies	Alternative web design	Relative score between two web designs	Improvement between two web designs
Success	Success	95.4	90.9	104.9	4.9
Content	Time taking the task, min. *	43.3	51.7	119.4	19.4
	Errors	9.8	14.2	144.3	44.3
	Knowledgememory	80.4	60.3	133.2	33.2
	Memory of memory	85.6	79.5	107.6	7.6
	Time toremember, seconds	1.9	3.7	192.2	92.2
Efficiency	Functioning in the tasks, min.	4.8	5.7	119.5	19.5
	Time spent in errors, min.	8.7	17.1	195.8	95.8
	Frequency to go for help	67.8	75.7	111.5	11.5
Efficacy	Taskscompleted at 100%	90.7	81.4	111.3	11.3
	Partialtasks	9.2	18.5	200.1	100.1
	Success	95.4	90.9	104.9	4.9
	Time to complete the task, min.	4.8	5.7	119.5	19.5
	Time spent on errors, min.	8.7	17.1	195.8	95.8
	Frequency to go for help	67.8	75.7	111.5	11.5
Usersatisfaction	Utility-control, minutes	34.5	30.1	114.3	14.3
	Likingforexercises	85.5	68.1	125.6	25.6
	Frustration or displeasure for exercises	14.4	31.9	220.7	120.7
	Help in the completion of tasks	84.7	72.2	117.2	17.2

In figure 6, is observed the evaluation of efficiency of websites to access and to search information.
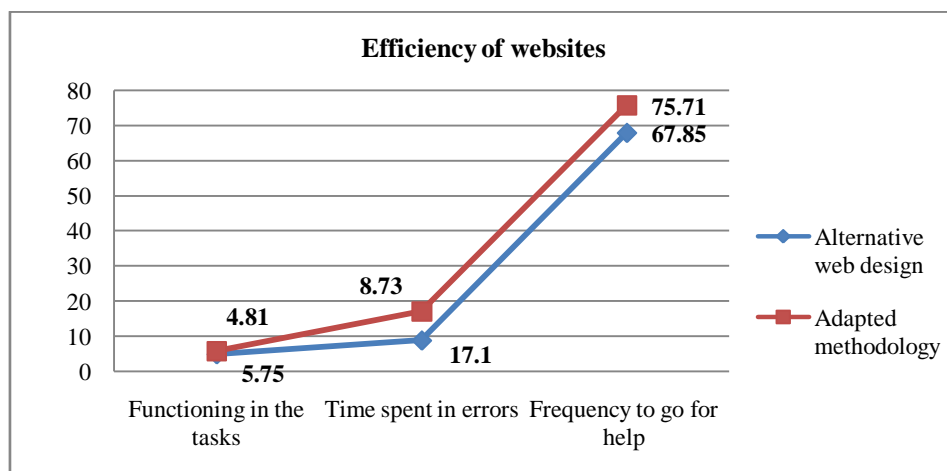

Fig. 6.   1 Geometric mean of efficiency in the usability evaluation of websites

In figure 7 is shown the evaluation of the efficacy of websites, with the adapted methodology is obtained a success of 95.46% and in fulfillment of the tasks a 90.72%.
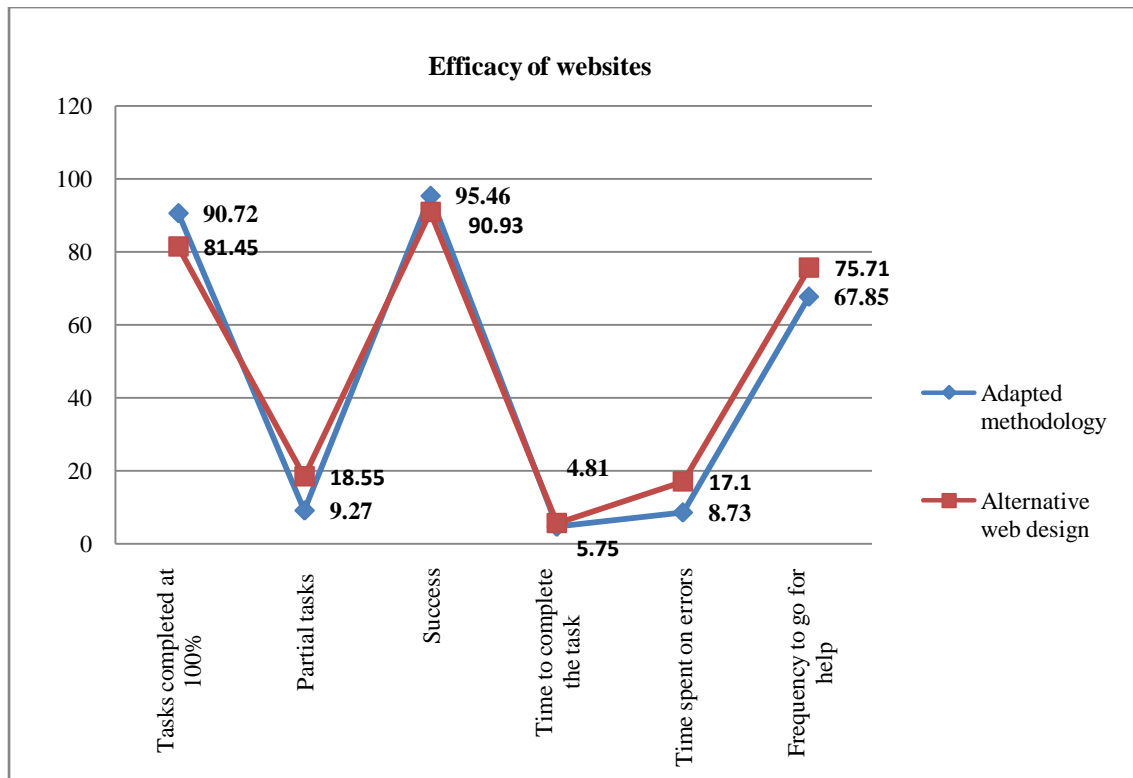
Fig. 7.   Geometric mean of efficacy in the evaluation of websites

In figure 8, evaluation of the user'ssatisfaction in their interaction and access to websites is observed.

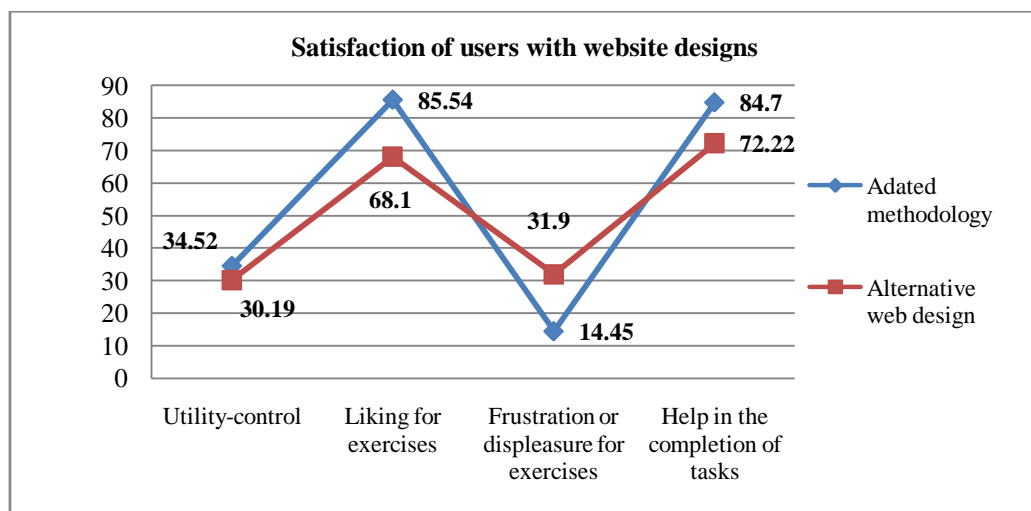Fig. 8.   Geometric mean of the subjective satisfaction in the usability evaluation of websites

Finally, considering the previous aspects (table IV),geometric mean of results show an improvement of 29.9% between websitedesign of the adapted methodology and the alternative web design (table V).

TABLE V.   GEOMETRIC MEAN RESULTS IN THE VALIDATION OF USABILITY OF WEBSITE

Usability metrics Evaluated in website design	Geometric mean per usability metrics of relative score	Improvement between the design of website of adapted methodology and the alternative web design
Success	104.98	4.98 %
Content	136.60	36.6 %
Efficacy	135.22	35.2 %
Efficiency	137.73	37.7 %
Satisfaction	138.86	38.8 %
Geometric mean of usability metrics between website of the adapted methodology and the alternative web design	129.97	29.9 %

IV.   CONCLUSIONS

Techniques applied in evaluating of the usability of websites were based on user-centric design (UCD)[14], this required implementing valuation instruments and involving potential users to test their interaction with website. Different evaluation methods used in usability test, such as heuristic test and user test helped us to understand and know participants interests, their needs of information, their subjective perception and observations. These methods favored to understand fulfillment heuristics and usability metrics in websitedesign, and so that we need concrete information about facility of use, efficiency, efficacy and subjective satisfaction; as well as main problems and limitations of the design, and the proposal to optimize this toward a better experience for users.

The results obtained in the usability test of website with the heuristic test, the observation guide and usability metrics give validity to the affirmation that using the methodology [3] in the design of web structure, provides a more accessible, simple and intuitive interface to the final-user. This improves efficiency in search of information because its structure is organized, coherent and consistent; therefore, this ensures efficiency of website's operation to facilitate navigation to the users, allow them to access more quickly and less time to elements and content of pages; and it provides satisfaction to the users during their interaction, adapting website to theirs real needs of search.

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Usability study of a methodology based on concepts of ontology design to define website structures

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ABSTRACT

Today, Web site design is used to make sites useful to users, with accessible functions, resources and information. Therefore, that design involves use of methodologies that allow an adequate structuring of them resources and organization, permitting users to access them quickly, easily and intuitively. This research consisted of a usability study oriented to website structure designers using a methodology based on concepts of ontology design. This study includes a planning to evaluate the design and the structure of website in aspects such as: ease of use, efficient access to information and performance on the tasks focused to total satisfaction of end user. Heuristic tests were used as diagnostic tools to evaluate usability of website design structures; these were supported by a heuristic evaluation guide and in the Sirius methodology**[3]**. The results obtained from them, allowed us to detect opportunities for improvement and optimization in website design, and in refining the Web interface oriented to end users.

***Keywords**—Ontology, heuristic tests, usability, websites*

I. INTRODUCTION

Web design includes: technical development, structure of information and visual design [11]. However, design of an accessible website requires an architecture model that is well structured and organized, functional, with useful content; and that involves usability since the beginning of its design. This is a quality attribute that measures ease of use in user interfaces (IU) [8].

This work describes a usability study directed to designers of websites structures, where they will apply an adapted methodology [13], with the objective to provide facility of understanding and use of the website structure, efficiency and efficacy to find information, functionality and satisfaction of website users.

II. DESCRIPTION OF PROBLEM

Evaluation of the usability is a process that establishes a reliable measure of the facility with which users interact with a system [5]. Therefore, usability evaluation is an empirical study with real users of the proposed system; this has the target of providing feedback on software development during iterative development life cycle [12]. The most important purpose of process or product evaluation is not to demonstrate its functionality but to improve it [4]. These concepts of usability are summarized in figure 1:
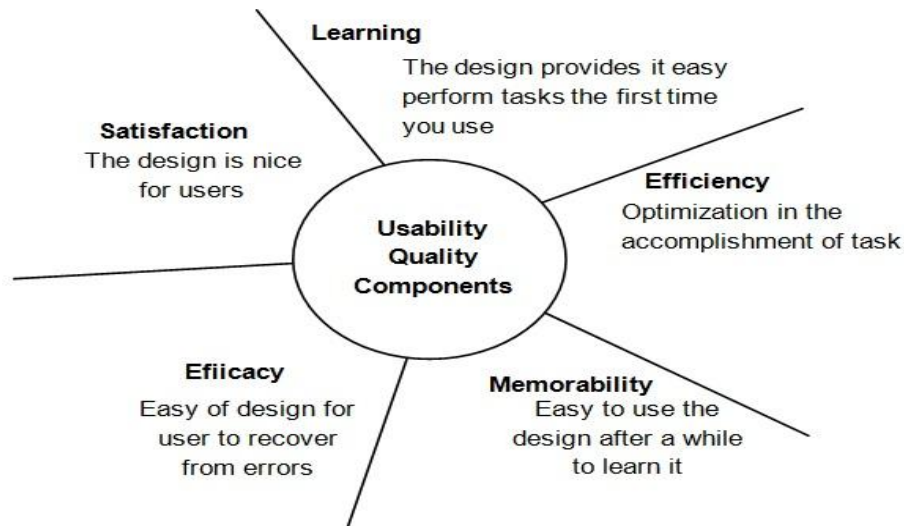
Fig. 1.   Diagram that defines five quality components of usability

In a previous work was defined a methodology of website design based on concepts of ontology [2] oriented to obtain a more usable website design; experimental stage to determinate its possible benefits was missing. This problem is present in mostly proposed methodologies.

Subsequently, in this research was realized an evaluation of the understanding of the users and the acceptance of the mentioned methodology [2], making it some improvements based on ontology design concepts [14] [10] and didactic techniques [6][8], this delivered as a result an adapted methodology [13].

III. EVALUATION METHODOLOGY

Our proposal is to design and to apply an evaluation schedule to measure degree of usability of the design of the structure of the website using the adapted methodology. Evaluation will help to identify aspects that are part of the design of the site, determining its simplicity and ease of use, efficiency and effectiveness in information access.

These assessments will help to identify opportunities for improvement and optimization in the adapted methodology, and in completing the design of user-friendship Web interface. These tests was oriented to measure aspects of usability of an accessible design, functionality to accomplish specific tasks of search of information, and finally total satisfaction of the end users.

In this study, heuristic tests [7],[3] has been applied; contemplating in these strategies usability metrics applied in Web design [9]. Two teams of designers were involve in define the structure of a school website, first one using adopted methodology and the other group by means of alternative method [1]. To avoid any statical bias, both teams use Adobe Dreamweaver CS5 and HTML to design the Web structure.

A. Evaluation of usability applying heuristic tests

The general description of the group of testers can be seen in table I, as well as description of material and equipment used is shown in table II. Mechatronics Laboratory of the Faculty of Engineering of the Autonomous University of San Luis Potosí was used to carry out the tests.

TABLE I. GENERAL INFORMATION OF THE GROUP OF EVALUATORS IN THE USABILITY OF THE WEBSITE DESIGN

Item	Description
Education Level	6 graduate, 4 Master degree students
Age	From 35 to 40 years old
Gender	6 women, 4 men

TABLE II. MATERIAL AND EQUIPMENT USED IN EVALUATIONS

Equipment and software	3 Laptops Hewlett Packard, 2 Laptops Toshiba and 1 Laptop Acer Epson Power Lite S6+ Projector. Operating system: Windows XP and Windows 7. Internet browser: Mozilla Firefox, Internet Explorer, Google Chrome.
Material	Heuristic test documentation (Digital and printed) Blank sheets, pencil.

Valuation instruments were delivered to evaluators for the adapted methodology and the alternative website design; they carried out the following activities:

- They opened Internet browser with each one of websites to be evaluated

- They accessed and interacted with each one of websites

- They applied the heuristics tests

- They registered the data obtained of the evaluations through Likert scales.

Afterwards, the records obtained were normalized, using statistics for their presentation as percentages. The meaning of the percentage scale of heuristic in evaluated pages was 0, for minimum expression and 100 for maximum expression.

IV. RESULTS AND ANALYSIS OF THE EVALUATIONS

The results of the heuristics (see table III) shown that the structure of the website with the adapted methodology has a more coherent, familiar and intuitive design (5); also, there is a better organization, homogeneity and visualization of information on its pages (2). These outcomes confirm a web design more oriented to the end-user (3).

TABLE III. AVERAGES OF HEURISTICS IN USABILITY EVALUATION OF THE WEBSITE STRUCTURE

No.	Heuristics generals	% Global percentage	
		Adapted methodology	Alternative method of Web design
1	Are the objectives of website specific and well defined?	92	92
2	Are the contents or services offer by website showed in a accurate and complete way?	96	88
3	Is the general structure of website oriented to end user?	88	80
4	Are the look & feel of website oriented to the objectives, characteristics, content and services?	84	80
5	Is coherent general design?	96	92
6	Is recognizable website general design?	88	88
7	Is website update periodically?	92	76

Heuristics of identity and information (see table IV) show that the web design using adapted methodology obtained improvement in identification of site and its objective (8, 10, 11) with a visible and informative logotype that supports this characteristic (9).

TABLE IV.   AVERAGES OF HEURISTICS OF IDENTITY AND INFORMATION IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of identify and information	% Global percentage	
		Adapted methodology	Alternative method of Web design
8	Is website identity show clearly across all its pages?	96	72
9	Is identifiable and sufficiently visible the Logotype?	100	76
10	Is the slogan really expressing that is the company and that services offer?	92	72
11	Is there a link with information about the company, website and webmaster?	96	72
12	Are there in company options for contact? (Email, telephone, postal address, fax...)	88	88
13	Is clearly showed information in articles, news, reports, etc.? About the author, sources, date of creation and review of the document.	88	84

In heuristics of labeled (see table V), design of the website using our methodology was more friendly and familiar (14), because the information on its pages was transmitted with a clear and congruent language (15, 16). This validates a website interface more accessible and user-oriented (17).

TABLE V.   AVERAGES OF HEURISTICS OF LABELING IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of labeling	% Global percentage	
		Adapted methodology	Alternative method of Web design
14	Is language used in website similar to users' language?	88	72
15	Is being used a clear and concise language in website?	92	80
16	Is there a friendly, familiar and intuitive language in website?	92	76
17	One paragraph = one idea, it is equal to one informative object.	96	88

In heuristics of structure and navigation (see table VI), the design applying first methodology shows a progress in organization of hierarchic structure (18), this facilitates to identify elements that compose them (19); and also give support to the experience of users in navigation through its pages (22), end-users recognize more quickly path to reach required information (24).

TABLE VI.   AVERAGES STRUCTURE AND NAVIGATION HEURISTICS IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of structure and navigation	% Global percentage	
		Adapted Methodology	Alternative method of Web design
18	Are you obtaining most appropriate organization and navigation structure with this design?	96	92
19	Does hierarchical structure maintains a balanced between depth and width?	96	88
20	Are all the clusters of nodes connected?	92	88
21	Are the links recognizable easily? Is state attributes indicated? what was visited, what is active, etc.	92	88
22	Has been controlled number of terms by element in navigation menus to avoid overload memory?	96	92
23	Is the answer of the system predictable before clicking on link?	88	84
24	Has been controlled in the design that there is not broken links?	100	88
25	Are there navigation elements that guide to user about where he is and how to return?	92	84
26	Are images recognized as links? Do these images include a title tag describing the target page?	88	84
27	Are not there redundant links?	96	88
28	Are there in design orphan pages?	96	88

The results heuristics of Lay-Out page indicate that web design of adapted methodology presents a better distribution of its elements (29, 30), because it was possible to identify its organization of its hierarchical structure and distribution of relations that comprise them (33); we obtain a web interface more intuitive for end-users and easy access, with properly distributing elements and avoiding visual and informative overload (31, 32); see table VII.

TABLE VII.   AVERAGES OF HEURISTICS OF PAGE LAY-OUT IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of page Lay-Out	% Global percentage	
		Adapted methodology	Alternative method of Web design
29	Does the design take advantage of areas of high informative hierarchy of page to show most relevant contents?	88	80
30	Is information overload avoided in website?	92	88
31	Is clean and without visual noise the web interface?	96	84
32	Does right the use of visual space in web site?	92	88
33	Is used correctly the visual hierarchy to express "part of" relationship between elements of the page?	96	88
34	Is controlled length of the page?	88	84
35	Are there any "empty areas" on page between informative objects to rest your eyes?	92	88

In both designs, we used heuristics of search but we gave less importance to these, because it was not possible to evaluate all the necessary attributes (see table VIII).

TABLE VIII.   AVERAGES HEURISTICS OF SEARCH IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of search	% Global percentage	
		Adapted Methodology	Alternative method of Web design
36	Is the search element easily accessible in website?	88	72
37	Is the search element easily recognizable in website?	88	76

Through the evaluations heuristics of multimedia elements, were observablein both web designs that image objects have a suitable distribution (44, 45), this reveals that web design of the adapted methodology shows improvement in the size and identification of these (42); see table IX.

TABLE IX.   AVERAGES HEURISTICS OF MULTIMEDIA IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of multimedia elements	% Global percentage	
		Adapted Methodology	Alternative method of Web design
42	Are the photographs well-trimmed? ¿Are these understandable? Had they a proper resolution?	96	88
43	Are visual metaphors recognizable and understandable by any user?	92	84
44	Do the images or animations provide some type of value added?	88	88
45	Has website been avoided the use of cyclical animations?	96	92

Evaluating accessibility heuristics was observable in both website designs (see table X) use of legible and visible fonts to easy-reading (46, 47), as well as compatibility of website with different browsers (50); also in any website was not necessary to install additional software applications (51); however, the web design with our methodology simplified this work of interaction to end-users with one improved

interface because it was taking care of distribution of elements, handling colors in its design (48), and images visualization with suitable size and description of the pages inside them (49).

TABLE X.   AVERAGES OF HEURISTICS OF ACCESSIBILITY IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of accessibility	% Global percentage	
		Adapted methodology	Alternative method of Web design
46	Was the font defined accord the content and large enough to help in readability of text in website?	96	88
47	Do the type of font, typographical effects, line width and alignment facilitate the reading in website?	92	88
48	Is there a high contrast between the color font and background?	92	84
49	Do images include a description tag that defines its content?	84	80
50	Is website compatible with different browsers? Is website correctly visible with different screen resolutions?	92	88
51	Can the user enjoy the whole content of website without he needs to download and to install additional plug-ins?	96	88
52	Is under control website weight?	92	84
53	Could be printed without problems the website?	88	80

The web design of the adapted methodology shows an improvement against the web design alternative, in the field of control and feedback heuristics. Our approach enables navigation control allowing users easy access information (54); through a visual design more intuitive in the composition of web interface (55); see table XI.

TABLE XI.   AVERAGES OF HEURISTICS OF CONTROL AND FEEDBACK IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of control and feedback	% Global percentage	
		Adapted methodology	Alternative method of Web design
54	Have the user under control the interface?	92	84
55	Is the user informed that it happens in the web interface?	84	68
56	Is the user informed clearly what is wrong and how can fix the trouble?	72	68
57	Have freedom to act the user?	80	72
58	Has been controlled the answer time?	80	64

In both designs of websites, heuristics of user-orientation was an import aspect, obtaining the data shown in table XII.

TABLE XII.   AVERAGES HEURISTICS OF USER-ORIENTATION IN USABILITY EVALUATION OF WEBSITE STRUCTURE

No.	Heuristics of user-orientation	% Global percentage	
		Adapted methodology	Alternative method of Web design
59	User's orientation. Where am I? How will I return? What have I visited? What is it going to happen here? Etc.	88	72

The design of the website with our approach presents an advantage against opposite, about several evaluated usability heuristics. This means that our methodology has the benefit of maintaining a more organized and simple structure, which facilities to users access to information in less time (efficiency) and interaction with a design more intuitive and consistent for a browsing experience more satisfactory.

V. CONCLUSIONS

The results obtained from the heuristic tests in the usability evaluation of the design of the website structure with the adapted methodology show a high score in the aspect of structure and navigation of 93.8% [13] against 87.6% of alternative method [1]; in accessibility was achieved 91.5% against 87% and in control and feedback, 81.6% versus 71.2%. The general average of usability heuristics was 90.6% in our proposal in contrast to 79.9% in the alternate approach.

The results derived from the evaluations allow validate efficiency and usability of website structure designed with our methodology. These results reveal that the structure designed had the following gains:

- A better organization, distribution and structuring of their pages and elements.

- Major accessibility in its web interface for the hierarchy of the relations and its concepts, providing a more intuitive and familiar browsing.

- There is consistency in the visual design of its pages, because it unifies similar colors, legible and visible fonts.

- This design provides descriptive information in each element: images, logotype, buttons and navigation options, among others.

- It provides satisfaction to end-user; also offers control and feedback on their pages, because the user is guided and helped, so that he knows where to have to move or where to navigate, supplying required information.

- A user-oriented design, with objects and content in consideration of real requirements and needs.

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Control of Direct Current Machine by the Change of Resistance in Armature Circuit

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ABSTRACT

The control of motor rotation speed by the change of resistor resistance value in armature circuit is called 'resistor control". For the regulation of resistance value R_0, included in armature winding circuit, we can use various technical solutions. The most used solution is the discrete variation of armature added resistance value by shunting its parts with contactors contacts.

Nowadays, the change of resistor resistance in armature circuit can be realized by shunting with a given porosity γ of resistor R_0 trough electronic keys. In this paper, we study the design of control system represented on figure 1.

Keywords: *Control of DC machine, change of resistance, armature circuit*

I. INTRODUCTION

DC motors consist of rotor-mounted windings (armature) and stationary windings (field poles). In all DC motors, except permanent magnet brushless motors, current must be conducted to the armature windings by passing current through carbon brushes that slide over a set of copper surfaces called a commutator, which is mounted on the rotor.[1][2]

The commutator bars are soldered to armature coils. The brush/commutator combination makes a sliding switch that energizes particular portions of the armature, based on the position of the rotor. This process creates north and south magnetic poles on the rotor that are attracted to or repelled by south and north poles on the stator, magnetic attraction and repulsion that causes the rotor to rotate.[3][4]

The dynamic behavior of DC machine is mainly determined by the type of the connection between the excitation winding and the armature winding including the commutation and compensation winding.

The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage or the field current will change the rotor speed.[5]

Speed control means change of a speed to a value required for performing the specific work process. This adjustment should not be taken to include the natural change in speed which occurs due to the change in the load on the drive shaft. The electrical speed control has many economical as well as engineering advantages over mechanical speed control. There are so many methods for controlling the speed of a DC shunt motor but field rheostat control method is most reliable, economic and independent of load on the motor. This method is only applicable when we want speed which is higher than the normal speed of the motor. In this method, an increase in controlling resistance reduces the field current with a consequent reduction in flux and an increase in speed. But if we want

to obtain low speed to control the low speed mechanical drive, we use armature rheostat control method. In this method, the speed at full load can be reduced to any desired value depending on the amount of resistance. But if we use both techniques in same machine then we can control motor from zero speed to maximum.[6] In field control the adjustment can be obtained by means of a small rheostat and relatively good speed regulation is obtained for all speed but with the armature control a bulky resistance is required. So if we use both methods simultaneously, cost of the machine will increase a little but we will get a large range of speed control. To neutralize the effect of power loss heat sink can be used. So by this method we can control the speed of a DC shunt motor to perform various tasks in effective and economic way.

II.   EQUATIONS OF ELECTRIC DRIVE POWER CHANNEL WITH REGULATION OF RESISTANCE IN ARMATURE CIRCUIT

The system of resistor control of electromotor M rotation speed with separate excitation is composed of additive resistance R_0 in armature circuit, transistor VT, transistor control system CS VT, current captor CC_1 with shunt RS_1, speed captor BR and control installation (figure 1)
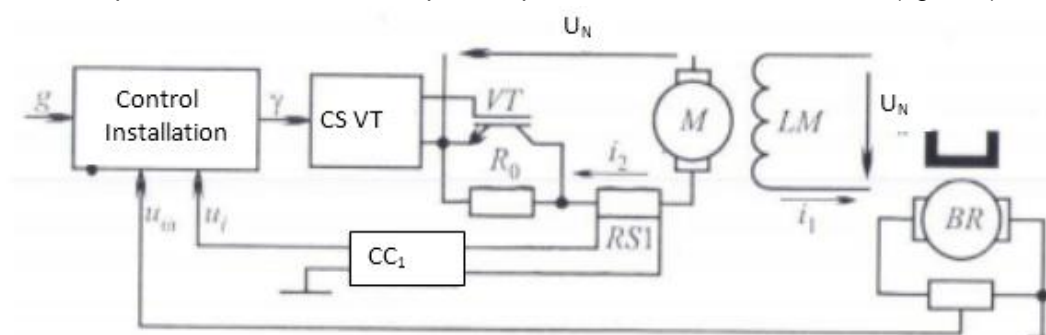
Figure 1: The circuit of resistor control of electromotor rotation speed

We shall assume that we supply in excitation winding and in armature winding direct current nominal voltage U_N. Additive resistor R_0 and transistor VT with control system CS VT constitute electrical transducer. The control of resistance value in armature circuit is done by the switch of transistor VT with porosity γ ϵ [0,1].

If the working period of transistor control pulses is much more higher than the time constant of armature circuit, then we can prove that the equivalent resistance R included in armature circuit is $R = \gamma R_0$

Thus the input signal of electrical transducer is the porosity γ ϵ [0,1], and the output is the equivalent resistance R. By varying R, we change armature current i_2 and the electromagnetic torque (moment) M.

To the electric drive resistor circuit in figure 1, we can match an armature equivalent circuit represented in figure 2.
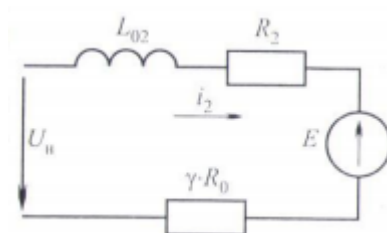

Figure 2: Armature circuit equivalent circuit

In that circuit, R_2 – active resistance of armature;

L_{02} – armature inductance;

γR_0- Additive resistance; $\gamma \in [0,1]$;

$E = \Psi \omega$ - armature e.m.f

$\Psi = U_N / \omega_B$ – constant expression;

ω_B – Basic armature rotation speed.

The state variables control system that describes the DC machine dynamic properties will look as follows:

$$\begin{cases} R_2^*.(T_2 p i_2^* + i_2^*) = 1 - \omega^* - \gamma R_0^*.i_2^*; \\ T_{Mech}.p\omega^* = i_2^* - I_r^* \end{cases} (1)$$

We have $i_2^* = M^*, I_r^* = M_c^*$

The equation (1) is nonlinear because of the presence of expression $\gamma R_0^*.i_2^*$.

The equation (1) corresponds to the structural circuit shown on figure 3. That system has two input signals: pulses porosity γ and current I_r^*.

γis the control signal while $I_r^*$is the perturbation.
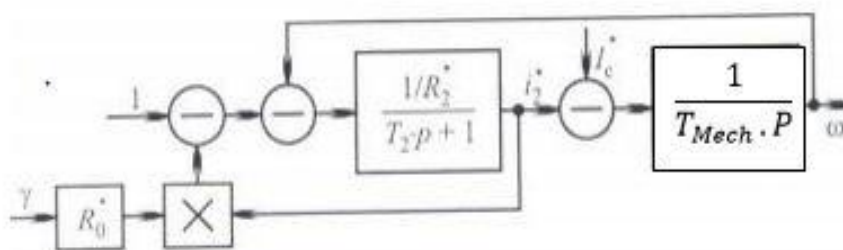
Figure 3: DC machine structural circuit with the resistance control in armature circuit

III. DESIGN OF CONTROL INSTALLATION

The resistance control system is constructed according to subordinate principle. It is composed of internal armature current loop and external speed loop. The current loop forms the control signal γ.

According to equations (1), established armature current value is

$$i_2^* = \frac{1 - \omega^*}{R_2^* + \gamma R_0^*}$$

From the last expression, when the porosity value γ increases the armature current i_2^* decreases. Let us introduce new control variable$x$, linked with γ. We consider$x = {}^1/_\gamma$.

Therefore with the increase of$x$, the armature current i_2^* will also increase.

The structural circuit of subordinate control system is shown on figure 3. The control system is composed of internal current loop with integral regulator. The transfer coefficient of current captor K_c^* is found from the condition $K_c^*.I_{max}^* = 1$, thus $K_c^* = 1/I_{max}^*$

p At the entrance of current loop, we install a current limit element. The maximal current value I_{max}^* should be limited to ensure given static and dynamic loads in electric drive mechanism and reliable functioning of collector-mechanism. As a rule, the armature maximal current value I_{max}^* is equal to 1,2;….;2,0.

The current limitation at a given level I_{max}^* can be achieved from the limitation of current loop input signal x_1^* by the value$x_{1 max}^*$. If we are given the armature current loop maximal value I_{max}^*, then
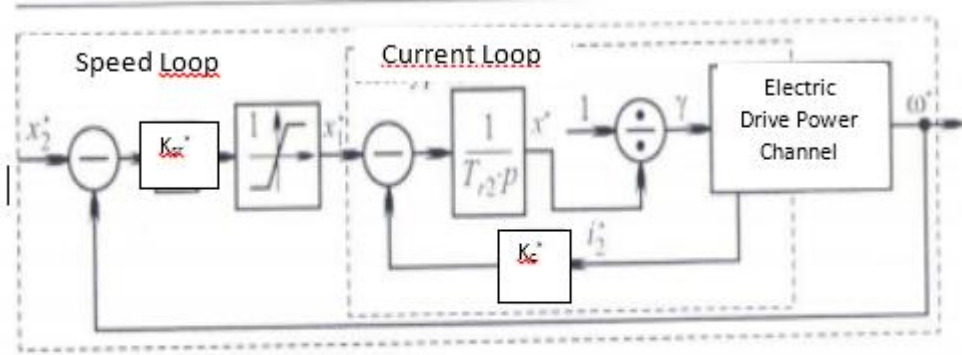
$$x_{1\ max}^* = K_c^*.I_{max}^* = 1$$

Figure 4: Structural circuit of resistance control system

IV. DEFINITION OF CURRENT AND SPEED LOOPS PARAMETERS

The parameter of integral current regulator T_{r_2} should be such that the transient processes in current control loop will have an etalon aspect. To the current loop corresponds the system of differential equations:

$$\begin{cases} T_{r_2}.px^* = x_1^* - K_c^*.i_2^*; \\ R_2^*.(T_2.pi_2^* + i_2^*) + R_0^*.\dfrac{i_2^*}{x^*} = 1 - \omega^* \end{cases}$$

That system is nonlinear on control signal x^*. For the determination of time constant for integral regulator Tr_2, we linearize those equations in neighborhood of the working point $[x(\infty)^*, i_2(\infty)^*]$

We observe that the mechanical time constant T_{Mech} is sensitively higher than the armature time constant T_2 and the speed ω^* practically does not change with current regulation, ie $\Delta\omega^* = 0$.

Considering p=0, $x^* = x(\infty)^*$, $i_2^* = i_2(\infty)^*$,

We have equations of stationary working regime:

$$\begin{cases} 0 = x_1(\infty)^* - K_c^*.i_2(\infty)^*; \\ R_2^*.i_2(\infty)^* + \dfrac{R_0^*.i_2(\infty)^*}{x(\infty)^*} = 1 - \omega^* \end{cases}$$

The solution of that system defines the stationary values of variables

$$x(\infty)^* = \frac{R_0^*.i_2(\infty)^*}{1 - \omega^* - R_2^*.i_2(\infty)^*} ; i_2(\infty)^* = \frac{x_1(\infty)^*}{K_c^*}$$

From linearization results we have the system of equations in variations:

$$\begin{cases} T_{r_2}.p\Delta x^* = \Delta x_1^* - K_c^*.\Delta i_2^*; \\ R_2^*.(T_2.p\Delta i_2^* + \Delta i_2^*) + \dfrac{R_0^*}{x(\infty)^*}.\Delta i_2^* - \dfrac{R_0^*.i_2(\infty)^*}{x(\infty)^*}\Delta x^* = 0 \end{cases} (2)$$

From the linearized equations system, we find the transfer function of current loop:

$$W_{cl} = \frac{\Delta i_2^*}{\Delta x_1^*} = \frac{1/K_c^*}{T_\mu^2 p^2 + d.T_\mu p + 1}$$

Where $T_\mu = d.T_2 \dfrac{R_2^*.i_2(\infty)^*}{1-\omega^*}$;

$$d = \frac{1 - \omega^*}{1 - \omega^* - R_2^*.i_2(\infty)^*}.\sqrt{\frac{R_0^*.T_{r2}}{x_1(\infty)^*.R_2^*.T_2}} \approx \sqrt{\frac{R_0^*.T_{r2}}{x_1(\infty)^*.R_2^*.T_2}}$$

The damping factor d of transient function will have the minimal value for $x_1(\infty)^* = K_c^*.I_{max}^* = 1$:

$$d_{min} = \sqrt{\frac{R_0^*.T_{r2}}{R_2^*.T_2}}$$

If we consider $d_{min} = \sqrt{2}$, then the current regulator time constant

$T_{r2} = 2.T_2.R_2^*/R_0^*.$

The current loop time constant T_μ will considerably depend on the drive working regime. For $\omega^* = 1 - R_2^*.i_2(\infty)^*$, the time constant will have the highest value $T_\mu = \sqrt{2}.T_2$.

If we assume that the current loop has transfer function

$W_{cl} = \dfrac{i_2^*}{x_1^*} = \dfrac{1/K_c^*}{\sqrt{2}.T_2p^2+1}$,

then the speed regulator transfer function is on technical optimum

$$W_{sr} = \frac{\left(\sqrt{2}.T_2 p + 1\right)K_c^*.T_{Mech}.P}{2T_{\mu 2}P.\left(T_{\mu 2}P + 1\right)} = \frac{K_c^*.T_{Mech}}{2T_{r2}} = K_{sr}^*,$$

where $T_{\mu 2} = \sqrt{2}.T_2$.

The set of electromechanical (mechanical) characteristics of closed loop control system with speed regulator will look as shown on figure 5.
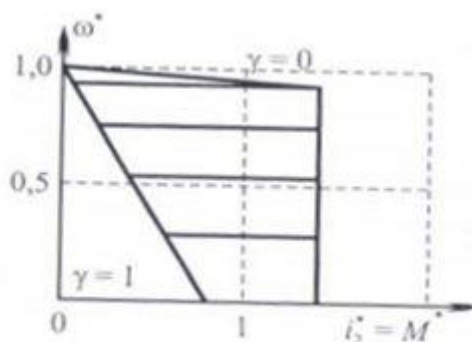
Figure 5: The set of electromechanical (mechanical) characteristics with closed loop control system

V.   CONCLUSIONS

The dynamic model of Direct Current electrical drive with control by the means of armature circuit resistance change is nonlinear on control signal. For the construction of current control loop, the design of regulators is done with linearization of equations (2). It is recommended to use integral regulator in current loop. At the input of current control loop, we install an armature current limitator. The speed control loop is external compared to current control loop and it should have a proportional regulator.

The region of speed regulation by commutation of resistor in armature circuit for the electric drive is limited by the value of resistor resistance R$_0$ (figure 5). The domain enlargement of speed regulation by reduction of expression R$_0$ will lead to high commutation survoltages in the transistor and its destruction.

The enlargement of speed regulation domain can be reached by in series switching of resistors, with transistor shunts. The reduction of porosity on transistor functioning should be done in opposite manner.

A deep resistor speed regulation is not energically efficient, because of energy losses.

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The effect of using solar chimney on reduced heating load in cold climate of US

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ABSTRACT

In a plethora of countries, buildings are adapted to the local climate condition using sustainable architecture techniques and materials, thereby the highest level of climatic comfort is provided. For example, the walls and roofs reflecting sunlight have been used for centuries in the warm regions of the world, while in the cold regions, the maximum use of solar energy has been tended.

The process of modernization has created a high density, thereby demand for fast and affordable constructions in cities has subsequently increased, resulting in reduced attention to environmentally sustainable architecture techniques that, in turn, has led to the financial loss and scarcity of non-renewable energy resources over long periods of time.

Regarding the energy crisis and the necessity of saving non-renewable energy, the reduced need to use heating/cooling systems is assumed to be one of the key goals in advanced building design.

The present study was conducted based on causal research and simulation. Design Builder thermal simulation software was used as the tool to this end. Therefore, a building with/out solar chimney was modeled and analyzed to identify the effect of solar chimney on the amount of energy used for heating.

The interior temperature of the building equipped with solar chimney and without mechanical heating systems was measured to be 22 °C. Given the ambient humidity of 40-60 percent (according to the field measurements), the measured temperature is within the comfort range. In comfort condition, regarding the ambient humidity of 40-60 percent, the comfort temperature is between 70-80 °F (22-26 °C)

Keywords: solar chimney, cold climate, reduced heating load

I.   Introduction

In a plethora of countries, buildings are adapted to the local climate condition using sustainable architecture techniques and materials, thereby the highest level of climatic comfort is provided. Increasing demand for housing has created a high density, therefore the need for fast and affordable constructions in cities has subsequently increased as well, resulting in reduced attention to issues like shortage of skilled worker (Escamilla et al., 2018), environmental sustainability, and energy efficiency. This, in turn, has led to the financial loss and scarcity of non-renewable energy resources over long periods of time (IEA, 2013).

The first study on solar chimneys was conducted by Bansal and colleagues in 1993. Using a mathematical model, they proved that solar chimney and correct design of the respective system may increase ventilation (Bansal et al., 2011). Comparing solar chimney and its conventional counterpart, Afonso and Oliveira (2010) confirmed the impact of sun's energy on the increased ventilation. As they suggested, solar chimney may effectively improve ventilation. They have also proved that increased thermal mass may reduce ventilation throughout the day and increase it during the night. Buchair (2011) investigated the optimum cavity width in a solar chimney and observed that in Algeria the optimal width is H /10 (H is the height of the chimney). Charvat et al. (2013) showed that high thermal mass may increase air velocity and consequently ventilation power at night. They also demonstrated

that using solar chimney during day may increase air velocity by 25 percent. Punyasompun and colleagues (2009) experimentally and numerically examined the performance of solar chimney in a multi-storey building in Bangkok.They presented two small-scale models of a three-storey building and compared two possible states, i.e. one where each floor has a separate SC channel and one where three floors are connected to a common SC channel. They finally concluded that the latter, i.e. a common SC channel for the whole building, may have a better performance.

Khedari and colleagues considered different types of solar chimneys and concluded that they have effective role in producing airflow. The performance of solar chimney in office buildings equipped with air conditioning were also studied in this research. It was conclusively found that daily electricity consumption of ventilation devices may decrease due to using solar chimney (Khedari et al., 2010).

Sudaporn and Bundit have experimentally investigated the impact of solar chimney with and without a wetted roof on enhanced indoor ventilation. They reported that depending on the ambient temperature and the amount of solar radiation, the outdoor chimney can reduce the indoor temperature by 1–3.5 degrees (Sudaporn&Bundit, 2014).

Today, considering the increasing importance of energy in the world, many studies have been focused on energy-efficient buildings design and construction (Rabah, 2011). Using solar energy to heat homes in the winter has been traditionally known as a solution in all parts of the world (Bodach et al., 2014). Today also using inactive solar systems can play an important role in reducing energy consumption in the world and preserving the environment (Tahersimaet all, 2017). These systems include using, whether directly or indirectly, solar radiation such as greenhouse system, double-glazed system, or solar chimney having been taken into account in this study (Chandel et al., 2015)

This technique has been used in building construction in many countries. For example, more than 100 buildings have been constructed in the western parts of India in Himalayan mountain ranges(Chandel et al., 2012).

In the following, the way of using solar chimney system is presented. Firstly, a building, here a school, was chosen as a sample in the cold region to be simulated by Design Builder energy analysis software and then results were subsequently analyzed.

Just like other strategy used in education, the division of labor has much importance in the industry with respect to productivity (Escamilla et al., 2018), Building industry also needs new strategy to reduce energy consumption in this sector.

II.   Research method

The present study was conducted based on causal research and simulation. The best and also the most convincing way to create a causal relationship is a precise experiment where the impact of latent variables is controlled as well. Accordingly, a simulation was conducted using thermal software to identify the temperature effect of solar chimney system embedded in the southern part of an educational building in addition to observe other climatic principles in the project.

The validity of the Design Builder software has been proved in previous research.By using Virtual Simulation Game, energy consumption could be simulated. By visiting the main page of the software web page, it can be seen that the results presented by the software simulations have been validated and totally recognized by the United Kingdom's decision-making bodies through entering the climate characteristics of different areas (Design Builder 2015)

To achieve the research purpose and asses the effect of solar chimney on increased efficiency of modern buildings, the plan of a school in the cold city of Bojnourd was considered as the sample.However, this mean has some flaw such as technical difficulty like low speed and limit options.

III.   New methods of increasing energy efficiency in the world

In addition to the all requirements of indigenous architecture, today there are other new techniques to better adapt buildings to the climate conditions, decrease non-renewable energy consumption, and reduce environmental pollutants production (Tahersima et all, 2017). In cold climates, these

techniques called inactive heating systems may emphasize the storage of solar radiation in different ways. Some of these methods include: (1) absorption of direct sunlight, as illustrated in Fig. 4; (2) absorption of indirect sunlight, as illustrated in Fig. 5; (3) greenhouse, as illustrated in Fig. 6; and (4) solar chimney system, as illustrated in Fig. 7 (Holloway, 2011).

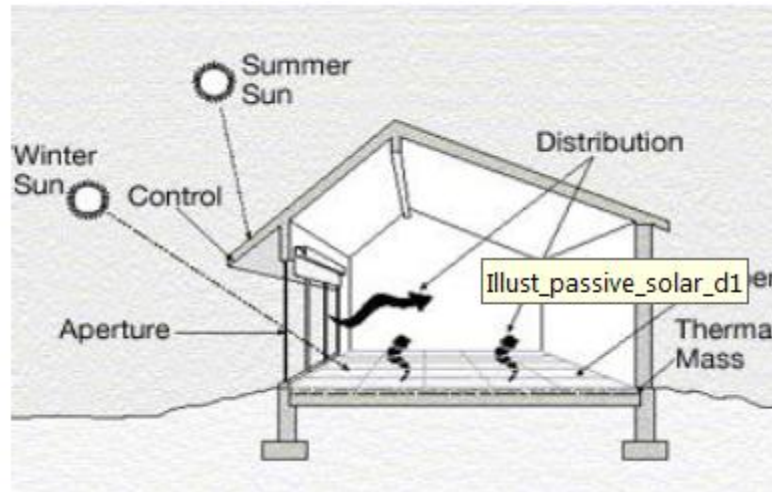This study was focused on solar chimney and its effects.
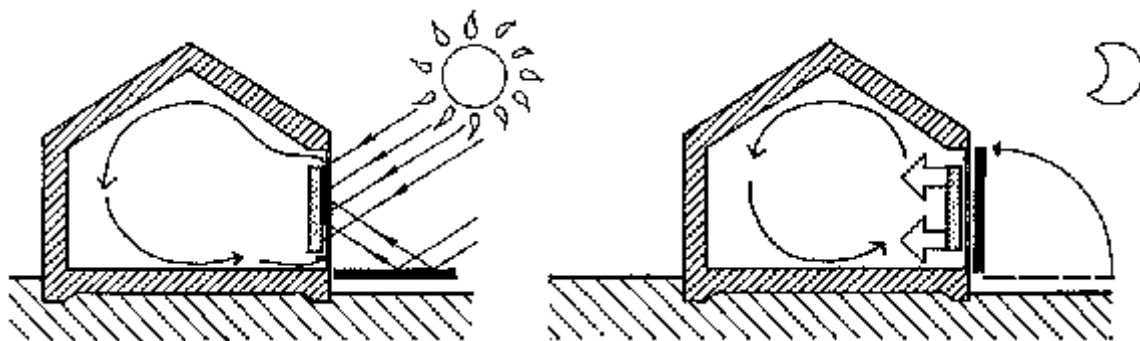

Fig. 1:   Internal gain of solar radiation

Fig. 2:   Using of indirect solar radiation

The greenhouse method is in fact the same traditional solution of covering south-facing balconies with glass or nylon (Fateh, 2010). In this technique, the greenhouse environment absorbs heat during the day, while during the night, absorbed waves with longer wavelength as the result of sequential reflections fail to exit due to the existing glass walls. In other words, the greenhouse acts like a heat-saving source at night (Tahersimaet all, 2018).

Greenhouse can be either freestanding or attached to another structure to grow plants (Holloway, 2011).

In the sample plan, in addition to being used for plant cultivation and maintenance, the greenhouse added to the space flexibility with an appropriate attachment.
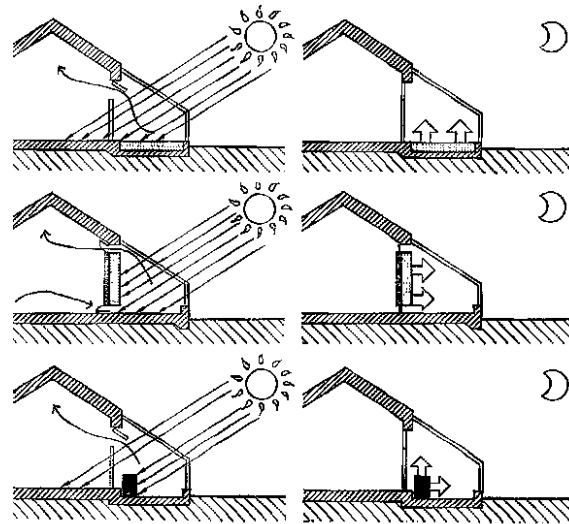
Fig. 3: Greenhouse strategy to warm the user space

Solar chimney is a system contributing to the air ventilation owing to chimney function. A simple solar chimney can be made out of a black tube (to absorb more solar energy) with suitable diameter a few meters above roof level(Tahersima, 2017). A thermal mass helping to retain heat for some time after sunset is used within these chimneys. Apart from being installed on the roof, this chimney can be installed on either the wall facing the Equatoror a separate surface higher than the roof level.

The solar chimney has a dual cooling-heating function. That is to say, when the vent in the upper level of the building is open, natural ventilation can be created by allowing warm air to escape to the outside, conversely, when the vent is closed, warm air captured in the chimney can be drawn into the building (Holloway,2011).
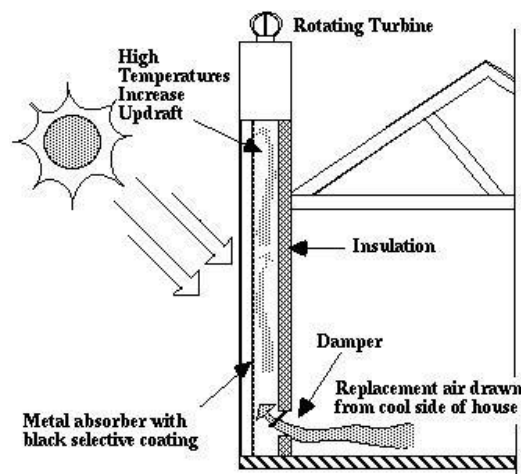
Fig. 4. solar chimney strategy to warm the user space

IV. Utilization of solar chimney system in cold climate

A residential complex plan in a cold climate has been considered to achieve the research purpose and investigate the effect of solar chimney on enhanced energy efficiency of buildings. The chosen sample is located in Shiraz, Fars province. It should be noted that in this research only a part of the complex facing southern has been modeled and studied. Fig. 8 shows the position of the solar chimney in the sample building.

4.1. Plan features in energy productivity
As shown in Fig. 8, East-West elongation of the building may result in the maximum use of southern sunlight in the winter (MozafariTorshizi&TaghizadehKurdi, 2005).
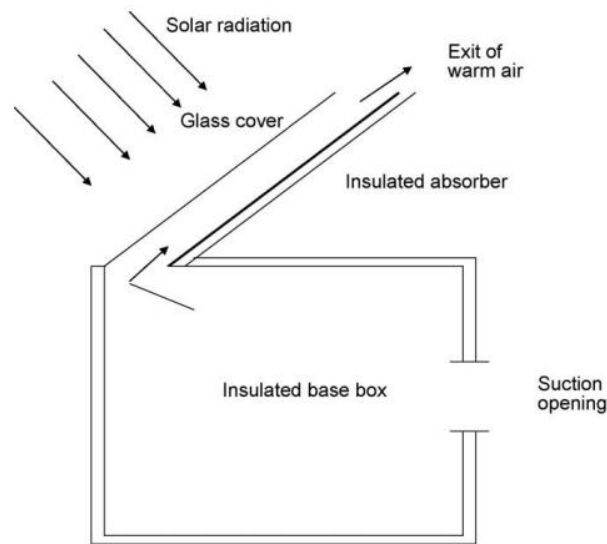
Fig. 5: The building, which use solar chimney to warm user space, is used for simulation (Mathur et al, 2006)

In the Southwest-facing wall of the building, a solar chimney system is used to save solar energy. Closed wooden shutters in summer may keep out sunlight. Installing solar panel on the sloped roof of the building may provide electrical energy required for the building by saving solar energy.Storing fragile material like glasses, Glass has been used in construction since approximately 2000 years ago.

The solar chimney is heated up in the winter with solar radiation, and transmits heat through the lower and upper vents to the interior. Vertical wooden shutters will also help the reflection of radiation and its entry into the building. In the winter nights, the absorbed heat will be trapped if shutters are closedhence the space acts as a source of heat. The interior materials of this space are mainly chosen fromhigh thermal capacity materialslikemud mortar with cement hardness that is mainly used for the inner liner of the solar chimney,

V. Modeling and analyzing the research sample using Design Builder's Energy Analysis Software

In this section, the results yielded from sample modeling with the features described in Design Builder software are presented.

As demonstrated in Figs 9 and 10, the indoor temperature is estimated to be 22 °Cwithout using mechanical heating systems.

Comfort - Occcupant, Class Rooms

EnergyPlus Output   1 Oct - 31 Mar (Zone conditions reported for occupied periods only), Monthly   Licensed
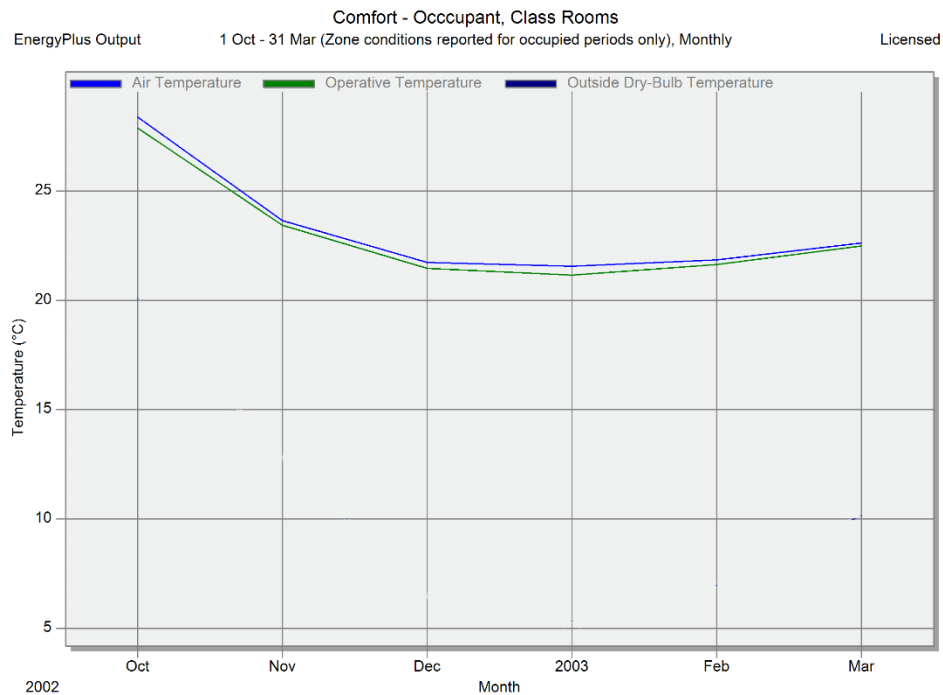
Fig. 6: The temperature of outside the building

Fig. 10 shows the flow of warm air generated by the applied system. As seen, average indoor temperatureis 22 ° C.

As seen in Fig. 11, given the fact that humidity of the environment is between 40-60 percent (based on the field measurements), this temperature is within the comfort range. In comfort conditions, with an ambient humidity of 40-60 percent, the comfort temperature will be between 70-80 °F (22 to 26 °C).
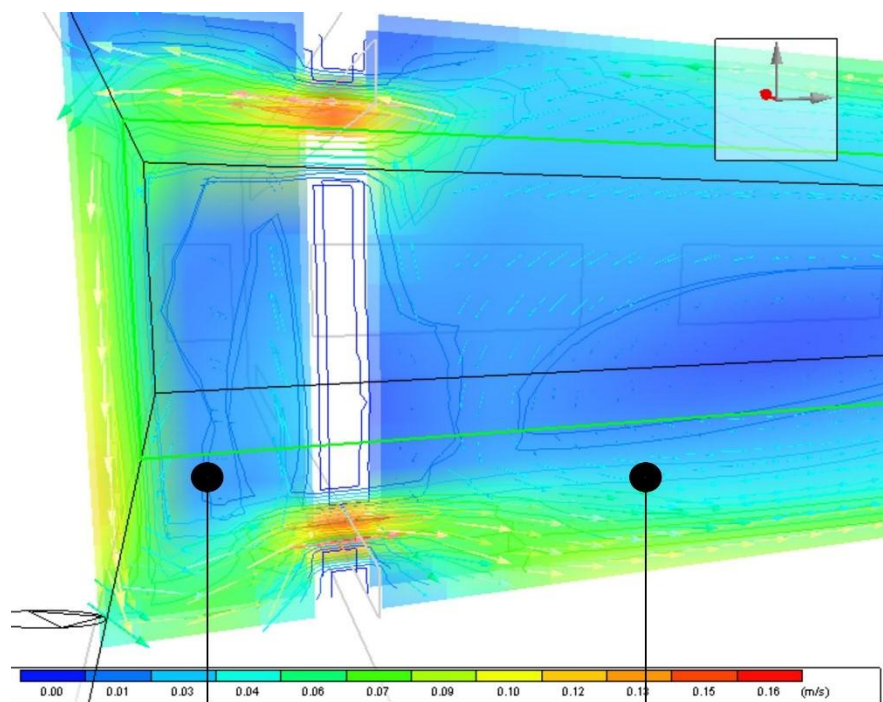
Fig. 7: Air flow in the user's space
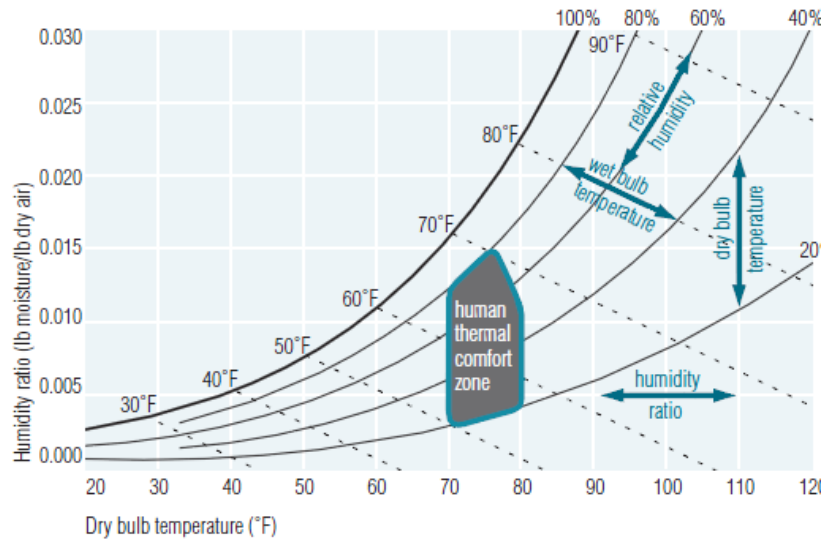
Fig. 8: Thermal comfort graph

VI. Discussion and conclusions

By using climate-friendly design techniques in the cold climate zones and also using solar chimney as one of the inactive solar systems, average indoor temperatureof the chosen sample substantially increased. Applying this technique has raised the indoor temperature of classes without using mechanical heating system. As seen in simulation of the sample, indoor temperaturereached 22 °C in winter. Regarding the humidity of the region estimated to be 40-60 percent, the mentioned temperature is in comfort range. However, according to field studies conducted on a winter day, when the ambient temperature ranged from 8-15 °C, the indoor temperature of the classes in the respective sample was measured to be 8-11 °C (Fateh, 2010). Accordingly, carful design and considerable attention to environmental sustainability in small- and large-scale architectural projects can be a major step towards saving non-renewable sources of energy and reducing environmental damages and air pollutants production without spending a lot of money. This issue is currently a matter of great importance in the design of architectural projects in the world.

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Numerical analysis of the density distribution within scored tablets

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ABSTRACT

Scored tablets provide dose flexibility, ease of swallowing and cost savings. However, some problems with scored tablets can be confronted like difficulty of breaking, unequally breaking and loss of mass upon breaking. This paper investigates the effect of score lines on the density distribution using continuum modelling. In keeping with previous work in the pharmaceutical field, a modified Drucker Prager Cap model is described briefly and used in the simulations. Coulomb friction is included between powder and tools. The microcrystalline cellulose (MCC) Vivapur® 102 was used to identify the model parameters using experimental tests with instrumented die, shear cell and diametrical crushing. The obtained results indicate that simulations may be useful not only to determine density distributions within tablets, but also may provide indications about performance of score lines.

Keywords— scored tablets; density distribution; Drucker Prager Cap; finite element modelling; die compaction.

I. Introduction

Tablets that can be broken in half or quarters will be scored by the manufacturer to make the process easier. The scored tablets present some advantages. The most important advantage is the dose flexibility. Ease of swallowing is another important advantage of scored tablets especially for big sized tablets [1,2,3]. Moreover, the scored tablets may reduce the costs of medication. Scored tablets reduce the number of tablets needed. Thus, we can reduce costs for both the producing industry as well as the pharmacy and the patient. When a tablet is broken in half, there is no guarantee that the drug dosage contained in each half. Scoring a tablet improves the chances that the drug dosage may be divided equally if the tablet has been cut exactly in the scored indentation. If this does not occur the tablet will fragment, and a proportion of the tablet will be lost. For more details about advantages, problems and performance indicators of score lines, see the review published by E. van Santen et al. [1].

In this work, numerical simulation was used to analyze the effect of score lines on the density distributions. The compaction behavior of pharmaceutical powders can be studied using the principles of continuum mechanics at a macroscopic level, i.e. phenomenological models. In continuum mechanical modelling, the powder is considered macroscopically as continuous and porous medium. The media is characterized by overall parameters such as cohesion, interparticle friction and mechanical properties such as Young's modulus and Poisson ratio which are depending on density during the compaction. In addition, as the applied load increases, the admissible stress in the tablet must be bounded in a domain which is bounded by one or a set of surfaces in the pressure and deviatoric space. This domain defines the yield surface. However, to describe mechanisms such as hardening and softening resulting from the loading and unloading of the powder, the domain expands

or contracts as the volumetric strain decreases or increases. This evolution is defined a flow function or flow potential.

A variety of continuum models from the soil mechanics literature have been developed from experiments on different geo-materials as described by Drucker et al. [4], Schofield and Wroth [5], Di-Maggio and Sandler [6], Gurson [7] and Green [8].

In this paper, the response of the powder behavior using the Drucker-Prager Cap model during die compaction with scored punches was studied. DPC model have been used for pharmaceutical powders by A. Michrafy et al. [9], S. Kadiri et al. [10, 11], J.C. Cunningham [12], and recently by L.H. Han et al. [13], T. Sinha et al. [14, 15].

The main objective in this work is to analyze the effect of the score lines on the pharmaceutical powder compaction using continuum modelling. This paper is organized as follows: Section 2 presents the materials and methods; parameters identifications are introduced in section 3. Results and discussions are in section 4. Finally, section 5 summarizes the conclusions.

II. Materials and methods

A. *The used powder*

The microcrystalline cellulose (MCC) Vivapur® 102 is often used as a pharmaceutical excipient. Characteristics of the powder MCC 102 provided by JRS (J. Rettenmaier and Sohne) is shown in Table 1. This powder having good flowability, compressibility and compactability, was used to identify the model parameters.

TABLE I.   PROPERTIES OF MCC VIVAPUR® FROM J. RETTENMAIER AND SOHN

Powder	Mean Particle Size	True density	Bulk density
MCC Vivapur 102	90 μm	1.59 +/-0.002g/cm^3	0.31 +/-0.02g/cm^3

B. *Drucker Prager Cap model*

The template The Drucker Prager Cap (DPC) model was described in several papers [9, 10, 11, 12, 13, 14, 15]. This model is implemented in the Abaqus Software. The yield function is defined with three surfaces represented in Fig. 1: the shear failure surface F_s defining the correlation between the cohesion d and the internal friction angle β, the elliptical surface (or Cap surface) F_c which can expand or contract according to the volumetric strain and the transition surface F_t between F_s and F_c. The evolution of the Cap surface is described with the hardening function pb which is the position of the Cap on hydrostatic pressure axis for each density state.
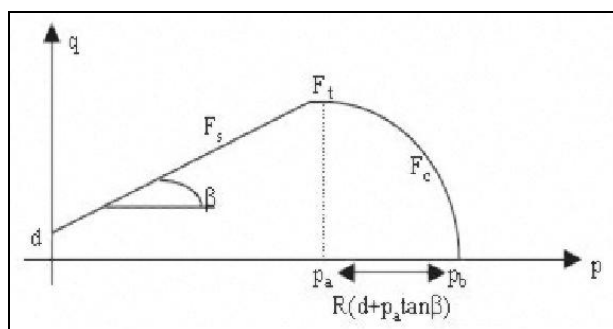

Fig. 1.   Drucker-Prager Cap model presented in the (p,q) plane.

$p = -1/3\ tr(\sigma)$ is the hydrostatic pressure, and $q = (3/2\ (S:S))^{1/2}$ is the Mises equivalent stress in which S is the stress deviator, defined as:

$$S = \sigma + pI$$

Where σ is the stress tensor, and I is the identity matrix.

Six parameters are required to define the yield surface of the modified DPC model: *d, β, p_a, R, p_b* and *α* and two elastic parameters, Young's modulus *E* and Poisson's ratio *ν*, are required for describing the elastic behavior of powders. Experimental tests with instrumented die, shear cell and diametrical crushing was used to identify these parameters.

The powder is characterized by mechanical properties (*d, β, E*) which evolve with the relative density of the powder, a constant Poisson's ratio *ν* and an evolution of the hardening function *p_b* with volumetric plastic strain during compression.

III. Material parameter indentification for the dpc model

A. *Cohesion and angle of inetrnal friction*

Diametral and uniaxial compression tests were used to identify the cohesion and the internal friction using the approach based on the shear failure surface of the DPC model [10, 13]. The evolutions of cohesion and friction angle are shown in Fig. 2 and Fig. 3. These results are similar to results obtained by Han et al.[10] for MCC Avicel PH101 having similar properties (mean particle size and true density) as MCC Vivapur 102. The results of the friction angle are rare and sometimes contradictory in literature. Stanley et al. [16] estimated the angle of internal friction of Titanium Dioxide using a shear cell. His results show that with increasing pressure, friction angle decreases.

Nevertheless, another result of Sinka et al. [17] shows rather a growth of the angle of internal friction and an exponential evolution of cohesion. However, our results are like those obtained by Han et al. [13] for Avicel PH101.
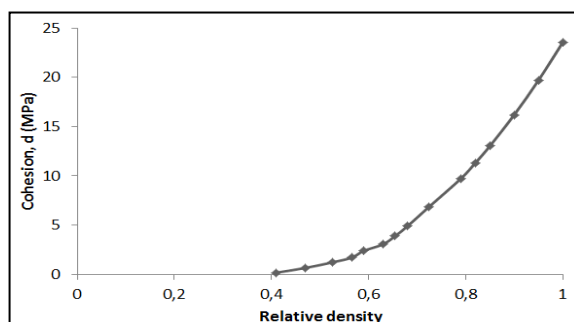

Fig. 2. Cohesion of MCC 102 estimated by axial and diametral tests with Drucker-Prager Cap model (fitted to zero porosity).
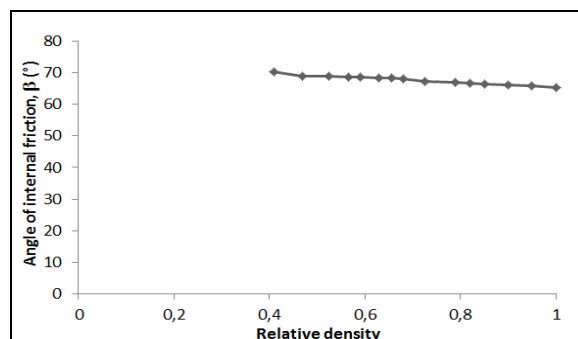

Fig. 3. Friction angle of MCC 102 estimated by axial and diametral tests with Drucker-Prager Cap model (fitted to zero porosity).

B. *Cap shape parameter R and hardening function p_b*

The position of the cap shape is determined by the cap shape parameter *R* and hydrostatic compression yield stress (hardening function) p_b. The parameter *R* is the eccentricity of the ellipse which defines the cap (Fig. 1). The hardening behavior in the model and the variation of the relative density is defined in terms of the volumetric plastic strain:

$$\varepsilon_p^{vol} = \ln(\rho/\rho_0) \qquad (1)$$

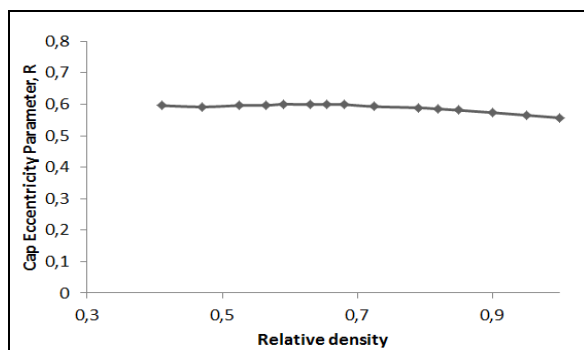Where ρ is the current relative density, and ρ_0 is the initial relative density on filling of die.

Fig. 4. Cap eccentricity parameter R.

From the experimental data of the compaction cycle, the hardening function pb and the eccentricity R were calculated and plotted versus the volumetric strain and relative density respectively (Fig. 4 and 5).

The trends are comparable with those published in the literature. Recently, Diarra et al. found similar trend of R and pb [18]. Han et al. found the same trend for pb, but the eccentricity R increases with relative density [13].
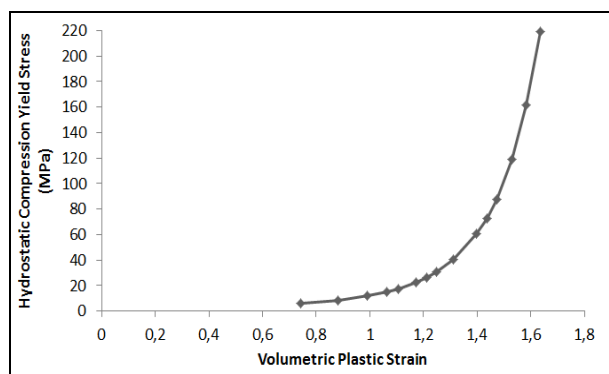

Fig. 5. Hydrostatic compression yield stress p_a.

C. Elastic parameters (Poisson's ratio and Young's modulus)

For Poisson's ratio ν, we use the relationship obtained by Long [19, 20]:

$$\nu = \alpha/(1 + \alpha) \qquad (2)$$

Where α is the transfer ratio (ratio of the radial stress to the axial stress). Compaction of the MCC 102 powder in a cylindrical die at the ambient temperature gave a transfer ratio in the range 0.4 - 0.45 [21]. For $\alpha = 0.4$ in Eq. (2), the Poisson's ratio ν is 0.29.

The Young modulus E was estimated from the simple compression test (without die). We use the macroscopic response of tablet that is given by the stress-strain curve. A cylindrical tablet of MCC Vivapur 102 is placed between two punches. To limit a deformation by bloc that lead generally to a non-uniform stress state, the contact between tablet and punches was lubricated. The obtained values are increasing with the relative density as plotted in Fig. 6.
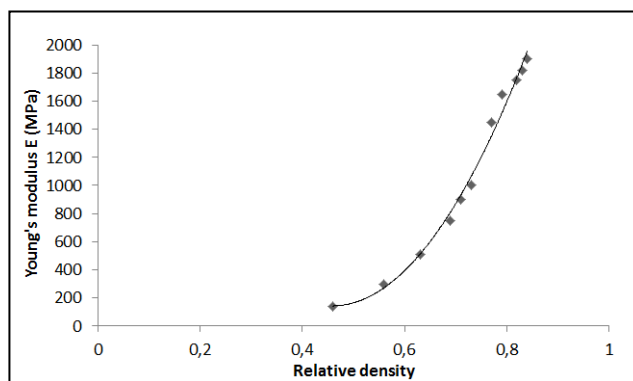
Fig. 6.   Young's modulus E plotted as function of relative density.

D. *Powder-die wall friction*

To complete the boundary problem of the compaction, the die wall friction coefficient is needed. During compaction, the powder friction at the die wall induces non-uniform axial stress and produces density gradients within the compact. The friction effect could be quantified by the wall friction coefficient. The friction coefficient can be determined by an indirect method based on Janssen-Walker theory [22]. This approach was applied by Michrafy et al. [23] to three pharmaceutical powders MCC 101, 102 and 105. We use the result obtained for MCC 102 that shows a decreasing of the friction coefficient in the first stage of densification (relative density < 0.55) and tends towards an asymptotic value approximately equal to 0.4. For the simulation, a mean constant value of 0.4 was taken.

IV. Results and discussions

The simulation of the uniaxial single-ended die compaction process of MCC Vivapur® 102 powder was conducted using the software Abaqus® (Simulia). The user subroutine (USDFLD) was used to update the elastic parameters and the parameters of the failure curves when the relative density changed using the visual FORTRAN compiler. The powder was modelled as a deformable continuum, while the punches and die were modelled as analytical rigid bodies without any deformation. The wall friction effect was considered by adopting a Coulombic boundary condition on the interfaces powder/wall and powder/punch. A constant friction coefficient equal to 0.4 was taken.

The numerical simulations correspond to two different geometries: flat-face and concave face. Due to the axial symmetry, half of the powder bed was meshed with elements of type "CAX4R" four-node axisymmetric elements and with a mirror effect we can see the whole tablet in Fig. 7. These simulations were conducted by imposing a displacement to the upper punch as in the experimental test. The model was validated by observing a good agreement between finite element prediction and experimental measurement of loading-unloading curves and by a comparison between predicted density distribution and experimental axial density presented in [11].
Numerical simulation produces a gradient of density distribution throughout the height of the tablet (Fig. 7). The friction prevents the powder from sliding along the interfaces of punches and die. As a result, very dense regions are developed on the upper edges of the tablet and low-density regions on the lower edges. These results are similar to those obtained by Aydin et al. [24] and Michrafy et al. [9]. Also, similar results were obtained by Han et al. [13] for MCC powder and recently by Diarra et al. [18] for ceramic powder.
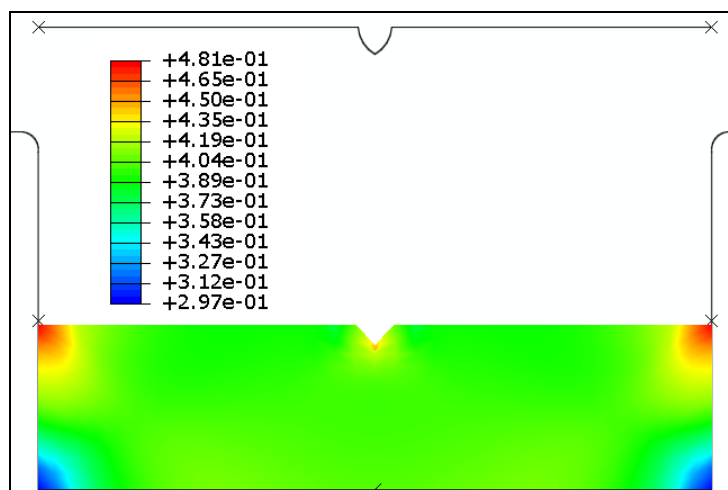
Fig. 7. Density distribution of scored flat-tablet after decompression.
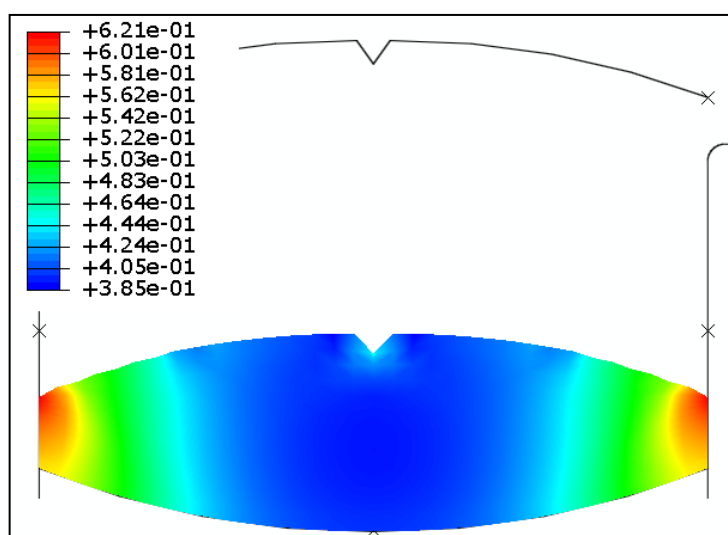

Fig. 8. Density distribution of scored concave-face tablet after decompression.

The punch geometry could also cause heterogeneity of density distribution. Fig. 8 shows a non-uniform density distribution of concave tablet. High density regions are developed at the edges of the concave tablet with low density regions near the tablet apex. The consequence of low and high-density regions is that the local properties of the powders are affected.

The strength of a porous material generally increases with density. From this point of view, low density regions may influence adversely the performance of the tablets during post compaction operations such as coating, packaging, transport and use. In addition, the localized disintegration and dissolution may be affected [25]. For flat and concave face punches, we have a dense region at the bottom of the score line. Fig. 9 and Fig. 10 show the evolutions of the relative density at the upper part from the die wall to the tablet apex for flat-face and concave face punches respectively. This result is qualitatively similar to X-rays tomography measurements obtained Sinka et al. [25].

The presence of the score line lead to particular effects. The tablet can break at the least dense region near the tablet apex. This situation may lead to a difficulty of breaking exactly at the score line; the tablet will be broken unequally. The risk of dose variability may be very dangerous for the patient because of the risk of taking subsequently light or heavy halves. Another problem can be met is loss

of mass, due to powdering and fragmentation at the score line when a tablet is broken. Loss of mass leads to loss of dosage, contamination and health hazards for others than the patient [1].
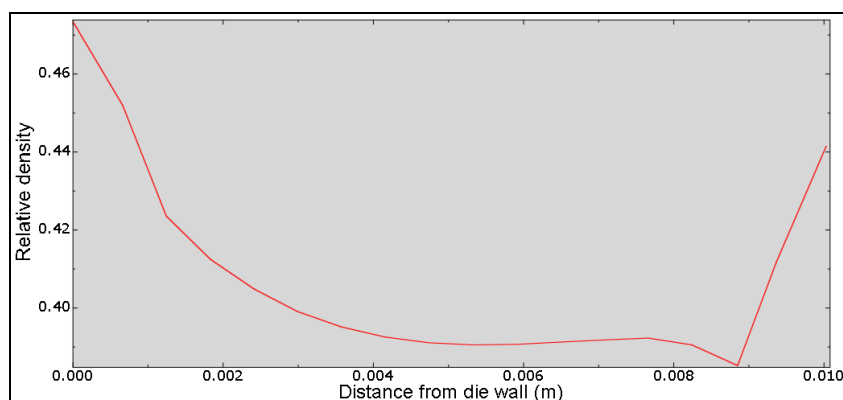

Fig. 9.   Relative density evolution at the upper flat face from the die wall to the tablet apex.
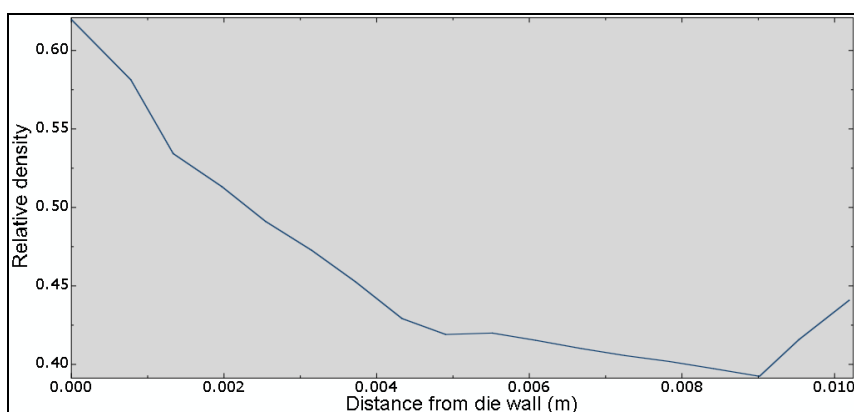

Fig. 10. Relative density evolution at the upper concave face frome the die wall to the tablet apex.

V. Conclusions

The Drucker Prager Cap model was successfully implemented for tablet compaction simulations in a commercial finite element software. The parameters governing the yield surfaces were estimated by experimental tests. The simulation reproduces the density distribution during compaction powder process. For both cases, flat and concave face punches, the obtained results show heterogeneity of the density distribution on the scored tablet at maximum compaction. Moreover, this heterogeneity continues developing during the decompression phase. For flat-face punches, very dense regions are developed on the upper edges of the tablet and low-density regions on the lower edges. However, high density regions are developed at the edges of the concave tablet with low density regions near the tablet apex. But, for both cases, flat and concave, we have a dense region at the bottom of the score line.

The tablet can break at the least dense region near the tablet apex and not exactly at the score line. This can lead to dose variability that may be very dangerous for the patient because of the risk of taking subsequently light or heavy halves. Moreover, the heterogeneity of density may lead to loss of mass, due to powdering and fragmentation at the score line when a tablet is broken.

The obtained result indicates that finite element simulations may predict not only density and stress distributions within tablets, but also may provide indications about performance of score lines. Finite element simulation can be an important tool to analyze factors influencing the performance of score lines like shape, size, curvature and thickness of the tablet and the form and deepness of the score line.

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